REFINER
AND NATURAL GASOLINE MANUFACTURER

Vol. 20, No. 2
FEBRUARY, 1941

A Gulf Publishing Company Publication
EDITED MONTHLY AT HOUSTON, TEXAS

GRADY TRIPLETT
Editor

Copyright, 1941

CONTENTS

Use of Additives in Automotive Lubricants 53
F. L. Miller, W. C. Winning and J. F. Lunc

Water-Wash and Heat Reduce Salt Content 96 Percent 61

Precise Plans Cut Clean-Out Period to Only 19 Hours 63

Elements of Vaporization and Condensation 65
R. L. Huntington

Minor Changes Prepare Column for Butane Manufacture 69

Hydrogen Content as a Basis for Correlating the Specific Heat of Liquid Hydrocarbons and Petroleum Fractions 70
John Griswold and H. A. Alves

Packed Columns for Close Fractionation 73
L. B. Bragg

Laboratory Oxidation Tests for Lubricants 83
F. Jostes and A. Hann

Small Stocks of Heavy Fuels Chief Inventory Problem 90
L. J. Logan

Larger Oil Demand Foreseen Despite Lower Exports 94

Upward Trend in Earnings for 1941 97
John E. Arens

Destruction of Cooling Towers 104
A. R. Moberg

Departments

Look Box ..... 51 and 109

Science and Technology 130

New Equipment 142

Business Notes 148

Catalogs and Bulletins 158

Advertisers' Index 160

SPECIALIZED OIL JOURNALS

Published by
THE GULF PUBLISHING COMPANY

OFFICE OF PUBLICATION
3301 Buffalo Drive, Houston, Texas

R. L. DUDLEY, *President*
A. L. BURNS, *General Manager*
S. W. ROBINSON, *Editorial Director*
J. KENT RIDLEY, *Managing Editor*
TOM W. NELSON, *Advertising Manager*

NEW YORK: Room 625, 250 Park Avenue, Dick Swinsky, Manager.

PITTSBURGH: 72 Vandergrift Building, Chas. A. Wardley, Manager.

CHICAGO: 332 S. Michigan Avenue, H. G. Fitzpatrick, Manager.

LOS ANGELES: 425 W. W. Wilson Building, Huntington Park, California, Jay Curts, Jr., Manager.

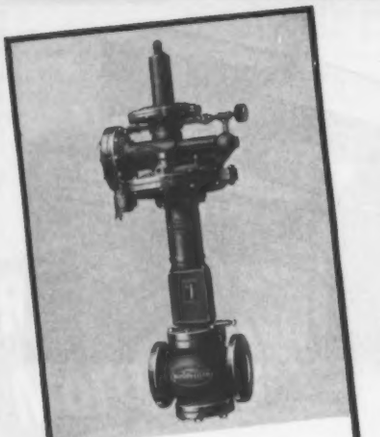
TULSA: 1304 Hunt Building, J. F. Carter, Jr., Manager.

FT. WORTH: 203 W. T. Waggoner Building, H. H. King, Manager.

Single copies 20 cents. Special issues single copies 50 cents. Domestic subscription price $1.00 a year. Canada and Foreign subscription price $2.00 a year. Entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879. Advertising rates on application.

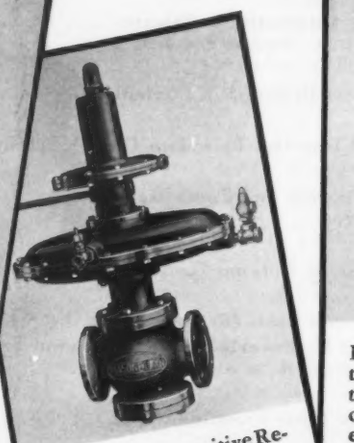
Copyrighted 1941 by The Gulf Publishing Company.

8 WAYS TO BETTER



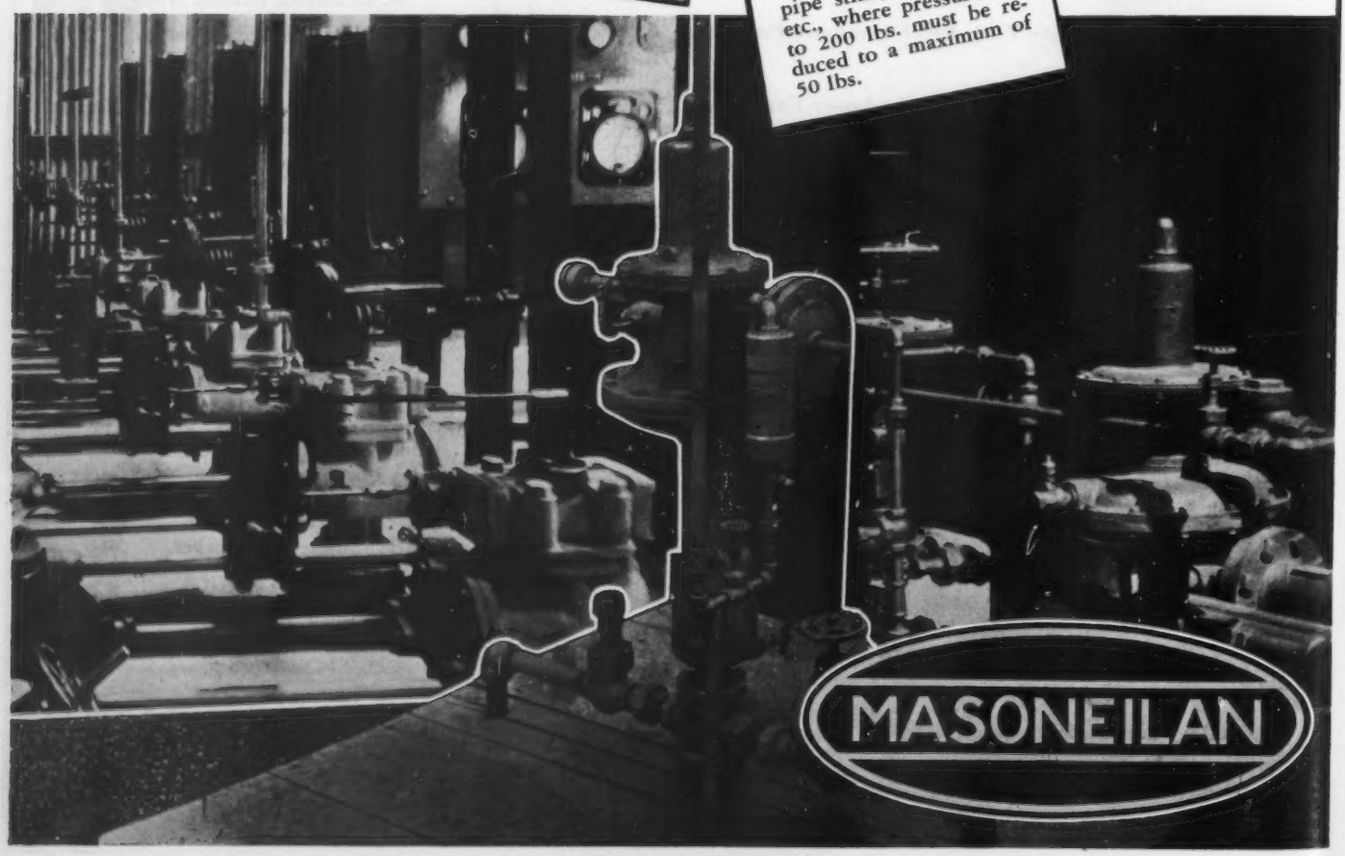
No. 27 Pilot (Air) Operated Regulator for gas, oil, steam or water lines, particularly under high pressure or handling large volumes. No. 47 for back pressure service.

No. 50–37 Pilot (Hydraulic) Operated Regulator for service where large main valves require a nonresilient operating medium or where air is not readily obtainable.



No. 29 Supersensitive Reducing Gas Regulator for controlling fuel gas to pipe stills, gas engines, etc., where pressures up to 200 lbs. must be reduced to a maximum of 50 lbs.

Exactrol Pressure Controller for service particularly where demand changes frequently and ease and speed of adjustment are important factors. Pilot mounted on valve or remotely. Fully indicating.



VOLUME 20, No. 2 FEBRUARY, 1941

REFINER
AND NATURAL GASOLINE MANUFACTURER

A GULF PUBLISHING COMPANY PUBLICATION

The Look Box

HOW words grow in meaning can be appreciated by starting with sabor—which in Europe is a wooden shoe. When the wearer of a wooden shoe walked about carelessly and destroyed property the wearer came to be known as a sabateur. The destruction he caused gained the designation sabotage.

Be Alert and Be Cautious

American workmen do not wear wooden shoes. Instead, the men in refining plants wear shoes especially designed to protect the wearer.

Still it is possible to be clad in wooden shoes in the figurative sense. Only by caution and mental alertness can the destruction charged to wooden shoes be averted.

This country is about to pass a gigantic piece of legislation, which is designed to throw the productive resources of the country into high gear for aid to England. Regardless of what men think of the move, they must guard against sabotage.

First, they must be careful what they do themselves. Carelessness may result in destruction of property. In such a case the workmen, even the man in the office, is in effect wearing wooden shoes. The call is for speed, and speed too often results in accidents. An accident which has no connection with deliberate destruction can keep a plant as idle as deliberate destruction.

So the men in refining and natural gasoline plants must be cautious about their work. Thus they will save time, save property and, above all, save lives.

It is likely that passage of the lease and lend bill will bring deliberate sabotage. Enemies will deliberately put on wooden shoes and set out to destroy the plants that make instruments of defense.

This prospect calls for the loyal workman to be alert. He must watch. When occasion demands he must act. Management will provide the course of action.

The full man power of the petroleum industry should gear itself to take care of the plants under their care. Thus they will serve to good advantage in a crisis which all men hope will not be long lasting.

NOT until the American people come to a proper appreciation of national defense will the program match expectations. Since defense concerns the people of a nation and its industries, it is well to discuss existing fallacies even in a publication devoted to this industry.

National Defense Is No Prosperity Jag

Specifically, the defense program is being adopted as a hope for prosperity or an opportunity for one group to gain advantage over another. These are sorry objectives.

Since there is guilt at home, the petroleum industry can be cited as an example. Too often in petroleum circles the demands for defense are looked upon as a source of increased consumption, which in turn is expected to yield higher

profits to corporations. Such may come as a consequence of expenditures, but to whatever extent profit is foremost in defense, the program will suffer.

Recently, delegations from two small cities bore down on officials in Washington, each striving to become the site for a bomber plant. Their expressions and their attitudes left no doubt that each was more concerned with an increased local payroll than with output of bombing planes. To each, the building of a war machine plant offered hope of prosperity.

Even a casual reading of the newspapers leaves the suspicion that labor groups are using the defense program as a means of forcing higher wages. Labor leaders of that stripe are a hindrance to defense, and should be classed with civic delegations which, by bickering, would delay plant building.

Even those in official Washington are guilty of holding the hope of prosperity above the true demands of the defense program. In several instances, men have pointed out that the national income promises to rise as high as $100,000,000,000 in a year under stimulus of the national defense program.

What corporation gets a profit, what city gets a bomber plant, what group gets higher wages are trivial matters in a critical period. That attitude tends to turn attention to spending as a delusion for prosperity while the necessary task of making war machines lags. No enemy is much concerned with the city in which an airplane is put together; neither is it concerned about the wage scale of the builders.

Such matters loom large when men have only small problems to consider. If world affairs are only half as critical as they are being painted, the issue of this day calls for generous thinking rather than petty scheming. This is no time for men to demand what they would not dare to seek in normal times.

Struggle Along With Progress

THE clash that comes through the advantage of standards on the one hand, and the necessity of advancement through research, is nowhere better shown than in petroleum. Right now there is a demand, at least a plea, from military sources for reduction in the number of lubricants for the internal combustion engine. That it would be desirable to have three or four grades of lubricants for the modern motor is evident. It would simplify buying, and it would simplify storing and using.

But the making of a better lubricant calls for moving away from standards. The laboratory reveals the need for change, and out of it comes a method for making a better lubricant. Thus another product is added to a long list.

That applies to motor fuels as well as other products. How can it be avoided without hampering research? The only answer is that this industry and the industries which it serves must struggle along with progress.

The American Chemical Society sets expansion of petroleum research at 539 percent in 11 years. Out of this has come much of the advance in cracking, all of the application of catalysis to refining, use of solvents in lubricant manufacture and so much more that pages would be required to record accomplishment. Because of research, current output of motor fuel, twenty-six billion gallons, could be increased to forty billion gallons.

There may be advantages in having just one gasoline or only four motor oils. But there is greater advantage in having improved motor fuels and better lubricants.

And More Will Be Added to It

THE petroleum industry can be pardoned for the pride it takes in its reserve figures, its accomplishment of doubling the output of gasoline from a barrel of crude oil, and more recently its ability to offer oil as a rival of coal tar for plastics and explosives.

What is discouraging is to have the uninformed accept these facts as proof of insufficient supplies or inadequate accomplishment. The crude oil reserve figure is being accepted as all the oil within these United States.

No one knows how much oil lies within the crust of the earth or how much of it is within this country. It should not be classed as limitless. That more will be found is certain. There is nothing to warrant hysteria. The supply is currently as large as the industry can support.

Furthermore, regardless of where it is found, how it is found or by what methods, the petroleum industry is best equipped to do the finding. Those who wail can not be trusted with the finding. That takes optimism.

Likewise, the industry is best fitted for learning how to make better use of whatever oil it may find. A barrel of motor fuel from a barrel of crude oil can be accomplished.

The end of crude oil will not halt the petroleum industry. It knows what can be done with shale and with coal. These are hydrogen and carbon, which are all petroleum technology requires.

Use of Additives in Automotive Lubricants*

F. L. MILLER, W. C. WINNING and J. F. KUNC,
Esso Laboratories, Standard Oil Development Company

ONLY a few years ago it was predicted that the motor lubricant of the future would consist of a highly refined mineral-oil base to which small quantities of special chemical agents would be added to secure the particular properties desired for superior engine lubrication.[16, 17] Today, progress in this direction is so rapid that it appears to be only a matter of time until most, if not all, of the predictions are realized. Many commercial oils which depend largely on addition agents for their special performance characteristics are now available.

At the present time, lubricating oils are generally refined to remove undesired components by some combination of distillation, acid treatment, solvent extraction, and clay filtration, the extent to which the treatments are applied depending considerably on the nature of the crude lubricating-oil stocks, the viscosity grade of the oil, and the qualities desired in the final product. There are definite limits to the qualities which can be obtained, even with the most suitable available crude and the judicious application of the most modern refining processes. Obviously, no refining method can impart to an oil properties which are not potentially present in the crude petroleum. With certain crudes and under certain conditions, the refining step may also remove some components essential to the best performance of the lubricant. Whether for imparting properties not present in the crude, or to replace components removed in refining, the use of a proper additive offers a means of obtaining the desired qualities. Furthermore, an additive often makes it possible to secure certain properties economically which are very costly to obtain by refining methods.

* Before the annual meeting of the Petroleum Division of the American Chemical Society, Detroit, September 9 to 13, 1940.

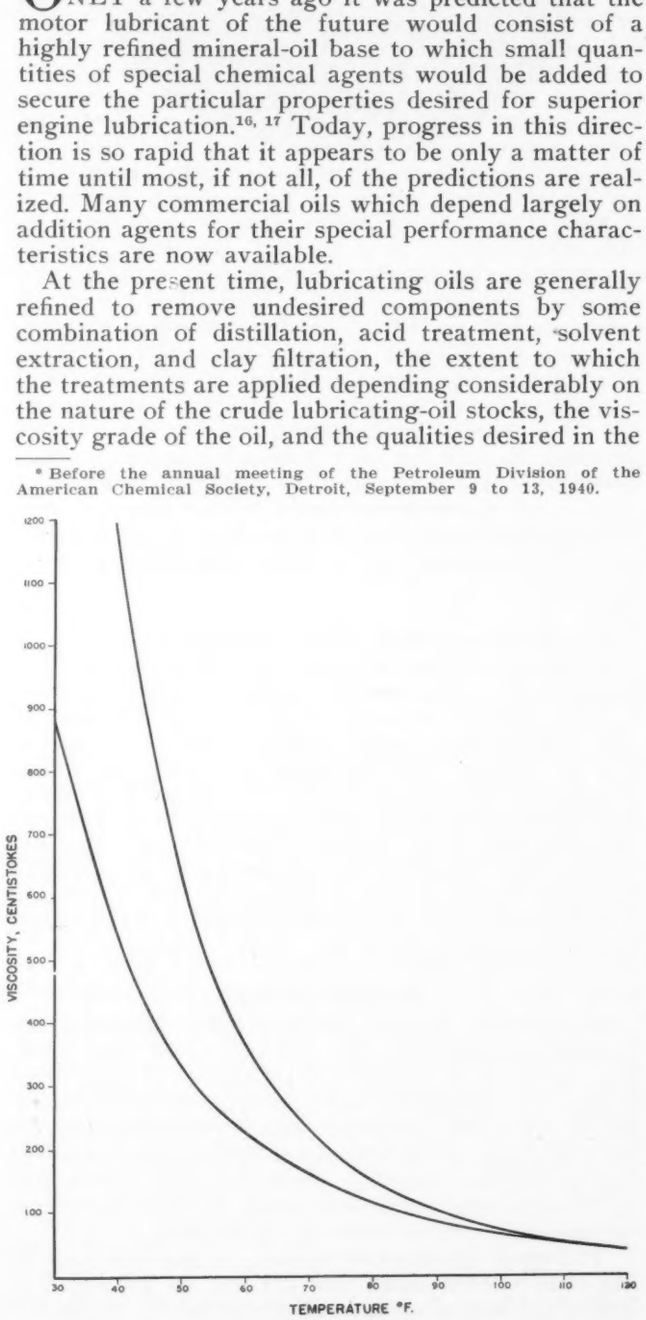


FIGURE 1
Temperature-Viscosity curves of two motor oils having the same viscosity at 150° F.

Demands More Severe

These factors naturally would have promoted the use of additives, even had lubricant requirements remained constant over the past decade. However, demands on lubricants have become constantly more severe, since automotive manufacturers have been continually increasing the specific power output of their engines. As the amount of power obtained per unit volume of piston displacement has increased, operating conditions have become more severe and the temperatures of pistons and valves and the pressures on rings and bearings, etc., have also been increased. Consequently, the present-day lubricant is not only exposed to greater deteriorating influences, but it is simultaneously required to carry greater loads. In addition, in many engines the lubricant is being employed to an increasing extent to cool hot piston surfaces and keep them from overheating, a responsibility formerly entrusted largely to conduction, via engine parts, to the cooling water. The resulting increase in the severity of service requirements has, in general, added to the advantages to be obtained by the use of additives in the lubricant. In the case of certain engines, satisfactory operation under severe conditions on ordinary mineral oils has become almost impossible, and the use of particular addition agents is essential.

The principal properties which determine the suitability of petroleum oils for the lubrication of engines may be considered essentially to be:

(1) Viscosity and Volatility;
(2) Viscosity-Temperature and Low Temperature Flow Characteristics;
(3) Chemical Stability;
(4) Detergent and Sludge-Dispersing Ability;
(5) Oiliness and Wear Characteristics.

The relative importance of these different charac-

TABLE 1

Effect of Polybutene on Viscosity and Viscosity Index of Motor Oils

Temp. °F.	VISCOSITY, SAYBOLT SECONDS		
	I 105 V.I. SAE 20 Oil	II 130 V.I. Oil Containing 1.6% Polybutene (Same Viscosity at 210° F. as A)	III Oil II Without Polybutene (105 V.I.)
0	32,000	12,000	7,000
30	5,200	2,800	1,450
70	920	650	330
100	351	280	150
130	168	150	84
210	56.5	56.5	43.5
300	38.7	39.5	34.5

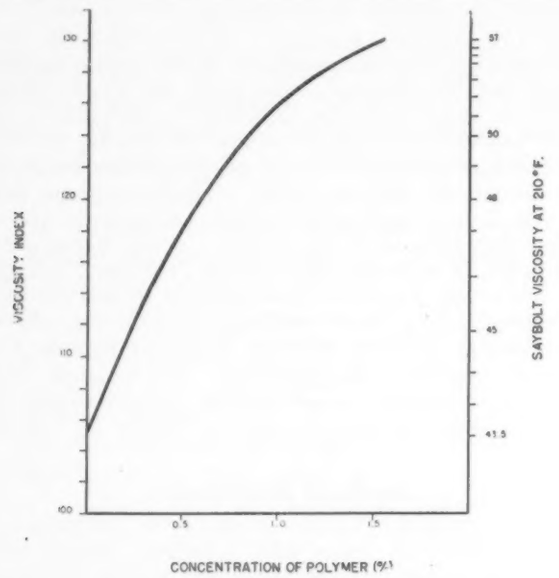


FIGURE 2

Effect of polybutene on viscosity and viscosity index

teristics, and the degree to which they can be modified through the use of proper additives, form the basis of this paper.

1. *Viscosity and Volatility*

It is necessary that a motor oil have the proper viscosity to maintain a fluid film under operating conditions. At the same time, its volatility should be low enough to prevent excessive evaporation from the hot piston and cylinder walls, since an oil film adequate for proper lubrication must be maintained at all times if the rubbing surfaces are to be protected from damage. Low volitility is also desirable to keep oil consumption at a minimum. Optimum volatility for a given viscosity level can be obtained through efficient fractionation and choice of crude, and is one of the few properties of an oil which cannot be modified advantageously with additives.

2. *Viscosity-Temperature and Low Temperature Flow Characteristics*

a. *Viscosity-Temperature Characteristics*

The viscosity of motor lubricants is extremely sensitive to temperature changes. This is illustrated by the viscosity-temperature curves shown in Figure 1 for two representative types of oil. The oil should maintain a relatively high viscosity on the cylinder wall and pistons at high temperatures, since it is this property which largely insures satisfactory lubrication and good oil consumption. At low temperatures such as prevail in the winter time, however, the viscosity should be kept relatively low, since the viscoscity under these conditions is the principal factor in determining the ease with which the engine may be started. If it exceeds certain limits, starting will be either extremely difficult or impossible.[1, 2] In other words, an oil of low viscosity-temperature coefficient or high V.I. (viscosity index) is desirable.

Choice of Crudes

By the choice of proper crudes and by suitable selective refining, motor oils of 80-100 and even 110 V.I. can be prepared economically. It is not practical to obtain higher viscosity indices by these methods except in special cases. On the other hand, it has been found possible in recent years to improve the viscosity index materially through the use of relatively small quantities, in the order of one to five percent, of certain types of high molecular weight polymeric linear chain compounds, and premium-quality motor lubricants are now being made successfully by such means. Certain butene polymers have been particularly effective for this purpose, and their properties and use have been described previously.[20, 28, 29] Their effectiveness is illustrated simply by the data shown in Table 1 and Figure 2. Column 1 in Table 1 depicts the viscosity-temperature characteristics of a 105 V.I. paraffinic SAE 20 motor oil as produced by conventional methods, and Column 2 represents a 130 V.I. SAE 20 oil having the same viscosity at 210° F., made by blending a lower-viscosity 105 V.I. oil (Column 3) with 1.6 percent of a polybutene. Figure 2 shows the effect of small concentrations of the polymer upon the viscosity and V.I. of a representative mineral oil base. A number of other linear types of compounds, such as rubber, hydrogenated rubber, certain cellulose esters and ethers, etc., have been tried for this purpose with varying degrees of success, depending on the stability of the compound, its relative effectiveness, cost, etc.[32, 33, 34]

b. *Low-Temperature Flow Characteristics*

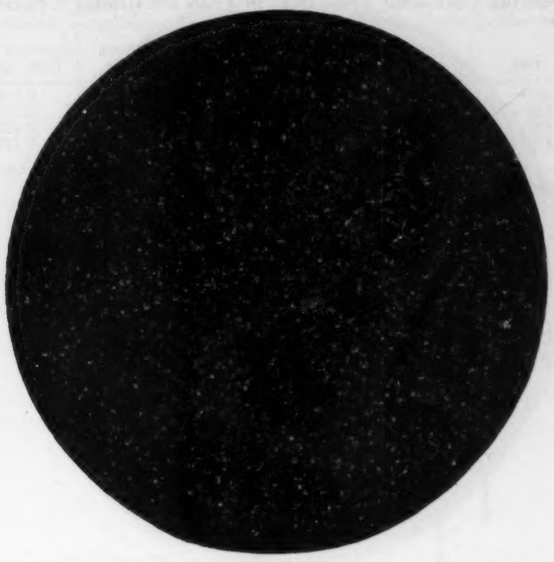
As oils are cooled, naturally-occurring high-melting components such as paraffin waxes, which are present in the paraffinic motor-oil stocks from Mid-Continent and Pennsylvania grade crudes, tend to crystallize out of solution and, in doing so, cause the oil to congeal. In this condition, the oil will not flow under low hydrostatic heads, and consequently it will not properly feed to the intake of the oil pump. Circulation of the lubricant to engine parts is therefore impaired until operation warms up the crankcase oil. Obviously, lubrication during this period is poor, and the engine surfaces may suffer damage.

Removal of Wax

Much of the wax can be removed conveniently by refining methods and the flow point, or pour point, lowered to around 20-30° F. Dewaxing to lower pour points is considerably more costly, and sub-zero pour points are often not economically obtainable by dewaxing methods. In consequence, the use of addition agents for reducing pour points has been the subject of considerable research leading to their successful development and commercial application.

The pour depressants appear to act (a) to keep the wax crystal small and prevent its growth, and (4) to prevent adsorption of the oil on the crystal.[4, 31] Both of these functions are typically colloidal, and presumably the effectiveness of the different pour depressants depends largely on their colloidal state

Paraffinic Oil; Pour Point, 30° F. 0° F.; 75 X.



Paraffinic Oil + 0.5 Percent Additive; Pour Point, 150° F. 0° F.; 75 X.

FIGURE 3

Photomicrographs showing effect of pour depressor on wax crystal formation

TABLE 2

Effect of Depressor on Pour Points of Representative Oils

OIL	Original Pour Point (°F.)	POUR POINTS (°F.) Concentration of Additive (%) 0.25	0.35	0.50	1.0	1.5
A	+25	0	..	—10	—20	—25
B	+20	0	..	—10	—15	—20
C	+30	..	—10	..	—20	..
D	+30	..	..	0	—15	..
E	+ 5	..	—10	..	—20	..

and behavior, particularly at low temperatures. Their effect on the wax particle size is illustrated in Figure 3, showing (a) wax crystals as normally formed on chilling the oil below its pour point, and (b) the crystals obtained on chilling the same oil after a pour depressor has been added. The effect of such an agent upon the pour point of various oils is shown in Table 2.

The most commercially important depressors are Friedel-Crafts condensation products of aromatics or phenols with chlorinated paraffin wax, the condensation being carried far enough to form complexes of relatively high molecular weight.[35] A large portion of the paraffinic motor oils marketed in the United States contain pour depressors of this type. Other condensation products[36] and voltolized materials[37] too have been reported to be effective. Certain soaps, particularly those of aluminum, have also shown some pour depressant properties, but they usually do not retain their effectiveness on prolonged use.[38] Various esters[39] and, recently, high-molecular-weight ketones,[21, 22] have likewise been reported to have pour-depressant properties. Many other materials have also been mentioned in the patent literature, but they do not appear to have been too successful.[40]

3. *Chemical Stability*

During its use in an internal-combustion engine, the lubricating oil deteriorates, undergoing chemical changes under the influence of the elevated temperatures and the air to which it is exposed. These changes result in the formation of carbonaceous or coke-like materials and of a wide variety of oxygenated products, including peroxides, acids, esters, alcohols, ketones, lactones, etc., as well as decomposition, inter-reaction, condensation, and polymerization products of these and other compounds.[11, 12, 15] Dehydrogenation and dehydration also play an important part, since upwards of 50 percent of the oxygen consumed is frequently recovered as water in laboratory studies.[9]

Harmful Products

Some of the products formed are quite harmful. The acidic substances tend to corrode bearing materials such as lead-bronze and cadmium alloys, thereby ultimately causing bearing failure. Deterioration products insoluble in the main body of the oil, and evaporation residues, tend to be deposited as lacquer-like coatings on vulnerable engine parts, particularly valves, pistons, and piston rings, and when sufficiently heavy, may cause the sticking or seizure of these parts. Insoluble materials may also join with the soot and other crankcase oil contaminants to form sludge which, in its worse forms, may stop up oil lines and thus lead to lubrication failure.

By selective refining it is possible in large part to remove the components tending to form insoluble oxidation products, and to prepare an oil highly resistant to varnish and sludge formation. At the same time, the refining step accomplishes other purposes, in that it also improves the viscosity index and volatility characteristics of an oil, often to an

TABLE 3

Bearing Corrosion Tests Run in 1936 8-Cylinder Engine

OIL	Bearing Type	Hours Run	Bearing Wt. Loss (gs.)
Base Oil*	Copper-Lead	30	0.418
Base Oil + 0.1% Additive B	Copper-Lead	30	0.104
Base Oil	Cadmium-Silver	4	0.422†
Base Oil + 0.1% Additive B	Cadmium-Silver	20	0.170†

* High V.I. SAE 20 Motor Oil. † Failed in 4 hour.

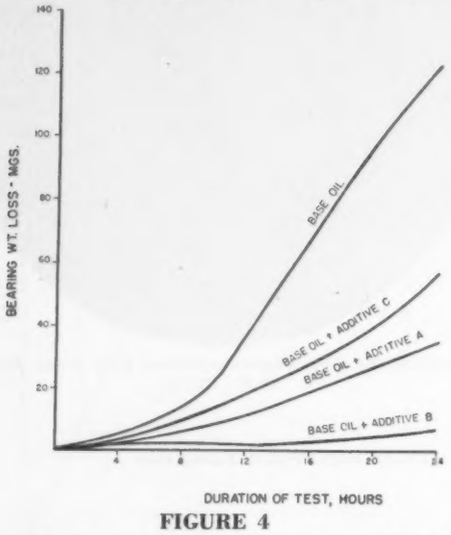


FIGURE 4

Effect of additives on corrosive action of a motor oil toward copper-lead bearings. Temperature of test, 325° F.

important extent. However, the tendency of oils to form acids on oxidation is not reduced by refining, since this tendency is a characteristic of the bulk of the oil, and is moderated mainly by the natural antioxidants found in many petroleum fractions. Some oils, either because they were originally relatively lacking in natural antioxidants or because the refining process removed part of those which were present, show tendencies toward acid formation in severe operation which may result in corrosion of special alloy bearings. Much attention has therefore been paid to the development of materials whose addition to such oils will render them non-corrosive in service, and will often improve them in other respects. Numerous products have been developed for this purpose of recent years, and have found actual commercial application.

These additives may function in different ways. They may act as antioxidants, thus retarding the harmful oxidation processes.[10] They may also act as so-called "metal passifiers" to deactivate the metallic surfaces in the engine and reduce their ability to markedly accelerate oxidation.[7] Some of these additives appear to serve in both of the preceding capacities.

Figure 4 illustrates the effectiveness of typical antioxidants and corrosion preventives as determined in a laboratory oxidation and bearing-corrosion test. The upper curve shows the extent of corrosion, as indicated by loss in weight of the bearings, which occurs with copper-lead alloy bearings on oxidation at 325° F. of a mineral oil which has little resistance to corrosion. The other three curves show the corrosion occurring under the same conditions with the base oil containing three different additives of varying effectiveness. The additives have reduced the corrosion as much as 50 to 95 percent. Such compounds are equally effective in engine service, as is depicted in Table 3, which shows the extent of corrosion of the same type of copper-lead bearings and of cadmium-silver bearings in an eight-cylinder passenger-car engine run up to 30 hours at high speeds (70 m.p.h.) and with high crankcase temperatures (300° F.) on the base oil and its blend with additive B, shown in Figure 4. It will be observed that the inhibited oil performed much better than the uninhibited base.

A review of the patent and other pertinent literature reveals that the classes of compounds most commonly advocated as antioxidants, bearing corrosion inhibitors, and metal passifiers are: (a) various types of phenols, (b) certain sulfur-bearing compounds, (c) numerous organic phosphites, and (d) certain of the amines. In a number of instances, combinations of one or more of these types are mentioned.

Certain phenols are reported to be effective antioxidants under some conditions. While thus far they do not appear to have been particularly effective in motor oils, at least one such compound, beta naphthol, has found application in high-quality turbine oils. Other phenols have also been claimed as lube oil antioxidants, and in these the hydrogen in the aryl nucleus is replaced by such substituent groups as are required to modify the compounds and obtain more desirable properties.[41]

Sulfur Compounds

Numerous sulfur compounds are reported to be antioxidants and corrosion preventives. Among these are dibenzyl disulfide[44] and sulfurized fatty oils[43], the latter being employed quite widely recently as compounding agents in special oils designed for heavy-duty gasoline- and Diesel-engine operation. Certain hydroxy thioethers combining both hydroxy and sulfur groups, and which presumably serve both as antioxidants and metal passifiers, are also of interest.[42] Many additional sulfur compounds have also been proposed[45], but their relative merits are not well established. In general, the sulfur compounds appear to act as metal passifiers, as well as antioxidants. This is probably particularly true of those depending largely upon sulfur alone for their effectiveness.

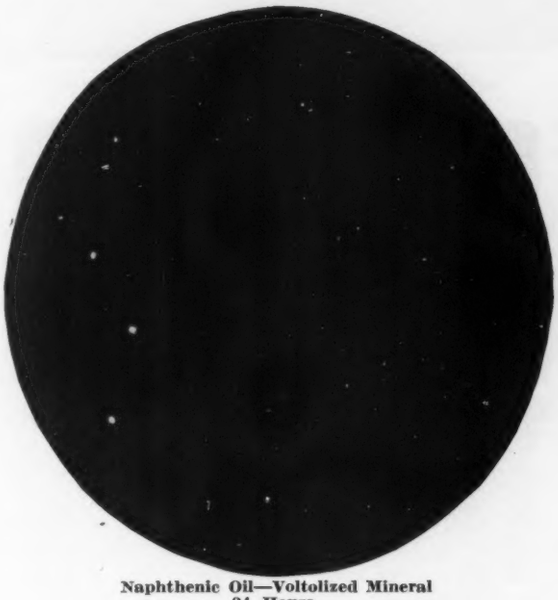
The alkyl and aryl esters of phosphorous acid (phosphites) are moderately effective antioxidants and, in addition, also appear to possess to certain degrees metal passifying and film-strength improving properties. Their antioxidant effect seems to be associated with the trivalent phosphorous nucleus which is readily oxidized to the pentavalent from (phosphate), and in the process stops the reaction chain responsible for its oxidation. Phosphites of one type or another, such as the triphenyl, triamyl-phenyl, and tributyl,[46] are available commercially and have been used successfully in the manufacture of non-corrosive motor lubricants.

Nitrogen Compounds

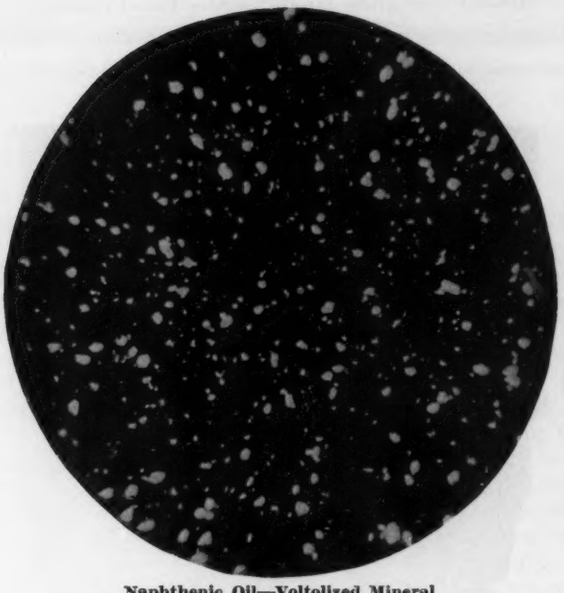
Various types of nitrogen compounds have been found to be effective antioxidants under some conditions, but in general they have not been sufficiently effective under the conditions existing in automotive-engine operation to find important application. The aliphatic amines, like dibutyl amine, triamyl amine, etc., and others such as cyclohexyl amine, are of interest because of their ability to stabilize the color of oils against deterioration caused by light and heat, and to protect metal surfaces against specific types of corrosion. The aromatic amines, including phenyl, naphthyl, and similar derivatives, all possess inhibit-

Naphthenic Oil—24 Hours.

Naphthenic Oil—72 Hours.



Naphthenic Oil—Voltolized Mineral
24 Hours.



Naphthenic Oil—Voltolized Mineral
72 Hours.

FIGURE 5
Effect of addition agents on sludge formation

ing properties to certain degrees.[47] Other nitrogen compounds and, recently, mixed amine derivatives containing other constituents, such as phosphorus in the molecule have been reported to be promising inhibitors.[48]

A number of patents claim the use of organo metallic compounds, such as tetrabutyl tin, triphenyl bismuth, etc., as antioxidants and corrosion preventives. Metal salts of alcohols and diketones have also been proposed. The agents are said also to reduce engine deposits effectively, but they are obviously costly to prepare.[49]

4. *Detergent and Sludge-Dispersing Ability*

Most past efforts have been directed to so refining an oil or compounding it with antioxidants that it will form in service none of the substances that impair engine operation. It is becoming increasingly apparent, however, that there are definite limitations to what may be accomplished in this manner. Many objectionable engine deposits have their origin in unburned fuel residues and such contamination as water and road dust. Many result from thermal breakdown rather than oxidation. Consequently, considerable attention has been paid more recently to the possibilities of preventing the deposition of oxidation and other deterioration and contamination products on engine parts by the use of so-called detergents and sludge dispersers. Neely,[19] Rosen,[23,24] Bray, Moore, and Merrill,[3] Stewart and Story,[27] Stewart, Moran, and Reiff,[26] Round,[25] and Larsen[13,14] have called atten-

Conventional Naphthenic Oil.

Naphthenic Oil + Disperser.

FIGURE 6

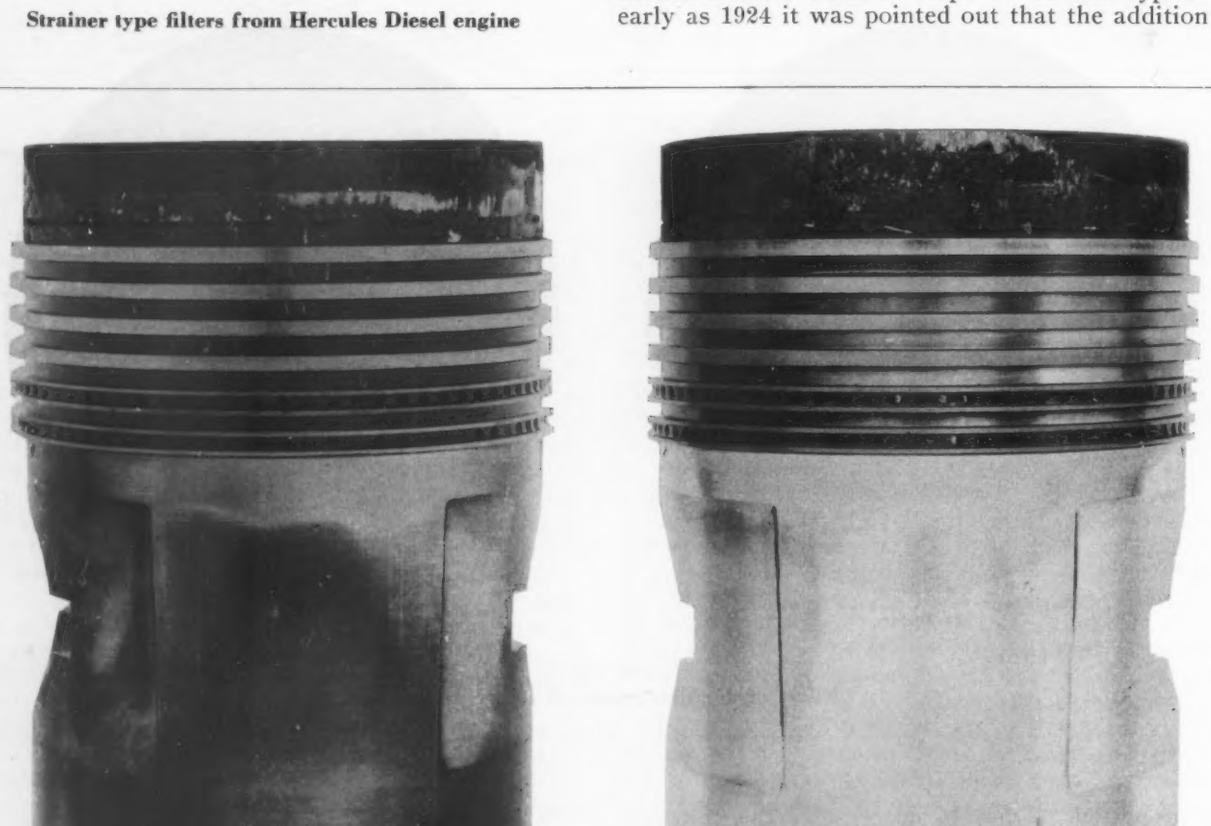
Strainer type filters from Hercules Diesel engine

tion to the benefits to be derived from the use of materials of this type.

Fatty Oils

One of the first materials to be advocated for preventing the separation of insoluble materials from oils was a voltolized fatty oil known as Elektrion.[5,6] The photomicrographs shown in Figure 5 reveal the degree to which voltolized material can keep oxidized materials dispersed in a mineral oil. In an engine, this dispersive ability prevents the deposition of varnish on piston parts, and retards the accumulation of sludge in the crankcase and on the filter. The last effect is illustrated graphically in Figure 6, which shows a screen-type oil filter from a Diesel engine operated under duplicate conditions on a conventional SAE 30 oil and the same oil containing a voltolized additive. Despite these properties, however, the use of voltolized additives up to the present time has been limited largely to service in certain European aviation lubricants. Other condensation and polymerization products have also been suggested for this service.[51]

A second class of sludge dispersers and detergents in which a great deal of interest is currently being shown includes metallic soaps of various types. As early as 1924 it was pointed out that the addition of

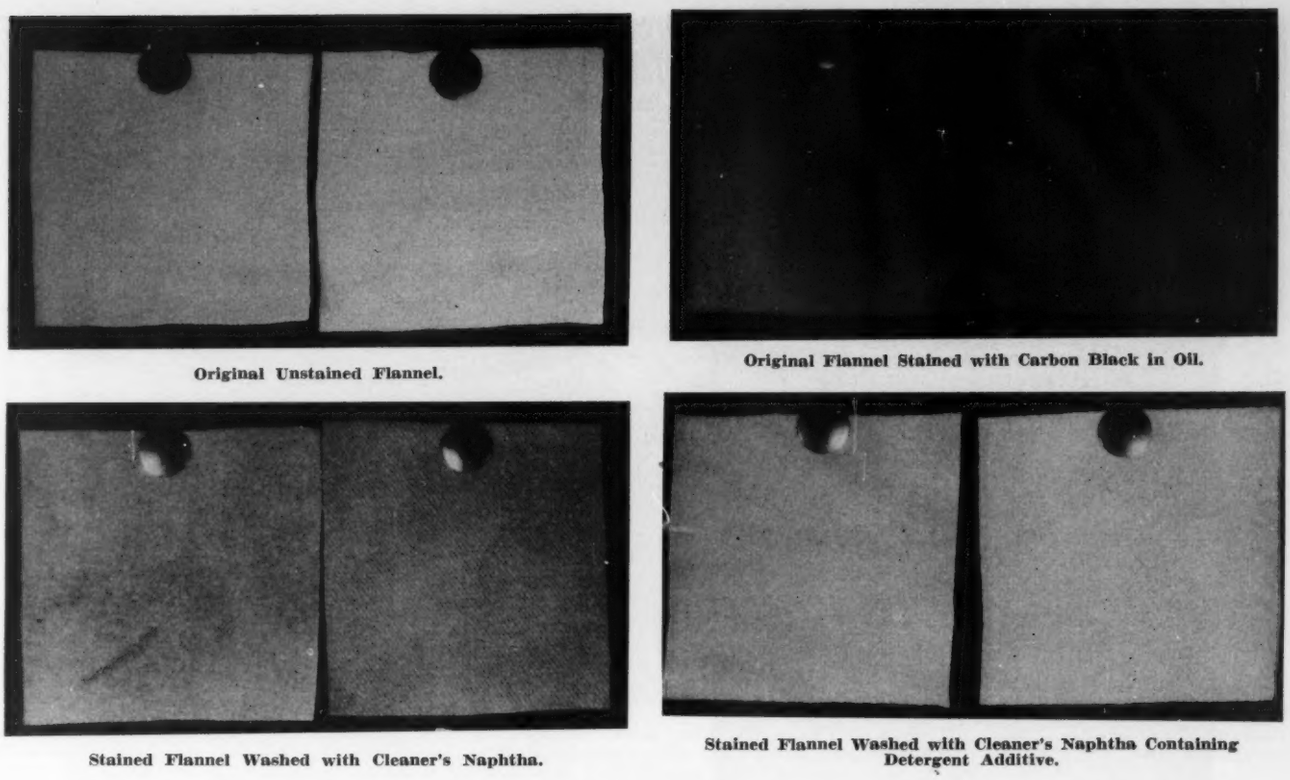


Conventional Naphthenic Oil—500 Hours.

Naphthenic Oil + Corrosive Additive—1000 Hours.

FIGURE 7

Pistons from Caterpillar Diesel engine after operation on compounded and uncompounded naphthenic oils



Original Unstained Flannel.

Original Flannel Stained with Carbon Black in Oil.

Stained Flannel Washed with Cleaner's Naphtha.

Stained Flannel Washed with Cleaner's Naphtha Containing Detergent Additive.

FIGURE 8
Launderometer tests on flannel specimens

small amounts of alkali metal soaps to oils would improve lubricating oil performance.[52] Subsequently several investigators recommended the use of tin, chromium, and nickel soaps, and motor oils containing such agents have been commercially available in recent years. The greater engine cleanliness obtainable with such soap blends was later discussed in detail by Evans and Kelman,[8] who found the soaps of some metals quite superior to others for this service.

Diesel Engines

More recently, it was shown that the inclusion of about 1 percent of aluminum naphthenate to a naphthenic oil would markedly reduce ring sticking and varnish formation in Diesel engines of the Caterpillar type. The same advantages were subsequently claimed for calcium soaps of phenyl stearic acid[30] and of dichlorostearic acid.[3] Various other soaps have also been proposed. However, such soaps are quite corrosive to copper-lead and similarly sensitive bearing metals, and as the oil ages in service the corrosiveness would become very serious in engines equipped with these bearings. Also, because the oils tend to thicken rapidly, frequent oil changes are necessary. Oils compounded with such soaps have nevertheless found extensive commercial use in Caterpillar Diesel engines because of their efficiency in maintaining engine cleanliness, and their shortcomings are catered to. The appearace of pistons from a Caterpillar Diesel engine run 500 hours on a conventional naphthene base oil alone, and 1000 hours on the same oil containing a soap-type additive, is shown in Figure 7.

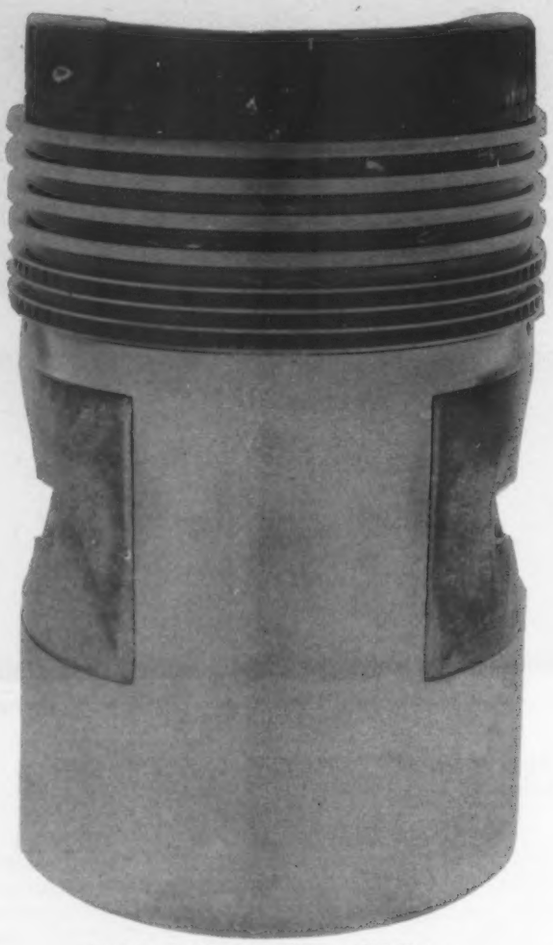
Soap Blends

Bray et al have likened the action of the heavy metal soaps in oils to detergency obtainable with solutions of water-soluble soaps in water. This effect is illustrated in Figure 8, which pictures cloth specimens, soiled with carbon black in oil, after scouring in a launderometer using cleaner's naphtha alone, and the same containing a heavy metal salt. The superior cleansing obtained with the latter is apparent, but whether this is necessarily related to performance in an engine is doubtful.

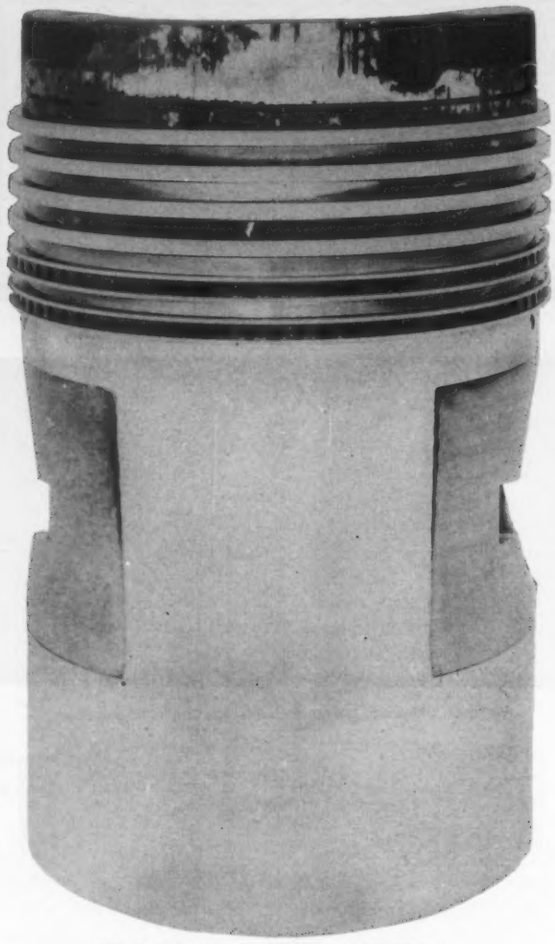
Much work has been under way during the past several years to correct the corrosiveness and other shortcomings of soap blends. Antioxidants and other anti-corrosion agents for use with soaps to improve their bearing-corrosion resistance have been proposed.[53] The employment of metallic phenolates instead of conventional soaps has also been claimed, and when properly made such compounds are said to be less corrosive than soaps.[54] Furthermore, metal-containing additives of undisclosed composition are now commercially available which possess corrosion-preventive properties and impart marked detergency to oils. The utility of such additives is illustrated in Figure 9, which shows pistons run for 1000 hours on a blend of a non-corrosive additive in a 40 V.I. naphthenic oil (A) and in a 100 V.I. paraffinic oil (B). In both cases, the pistons are in excellent condition.

5. *Oiliness and Wear Characteristics*

For most purposes, uncompounded mineral oils possess sufficient oiliness and film strength to provide satisfactory control of scuffing and wear. Whether wear can be reduced further and engine operation benefited by the addition of so-called oiliness agents has been the subject of much controversy. It has been fairly definitely established, however, that wear and the property of oiliness as shown by ordinary laboratory test machines are not necessarily synonymous.[18] It has been found, nevertheless, that under some con-



Naphthenic Oil + Additive—1000 Hours.



High V. I. Oil + Additive—1000 Hours.

FIGURE 9
Pistons from Caterpillar Diesel engine after operation on oils compounded with non-corrosive additive

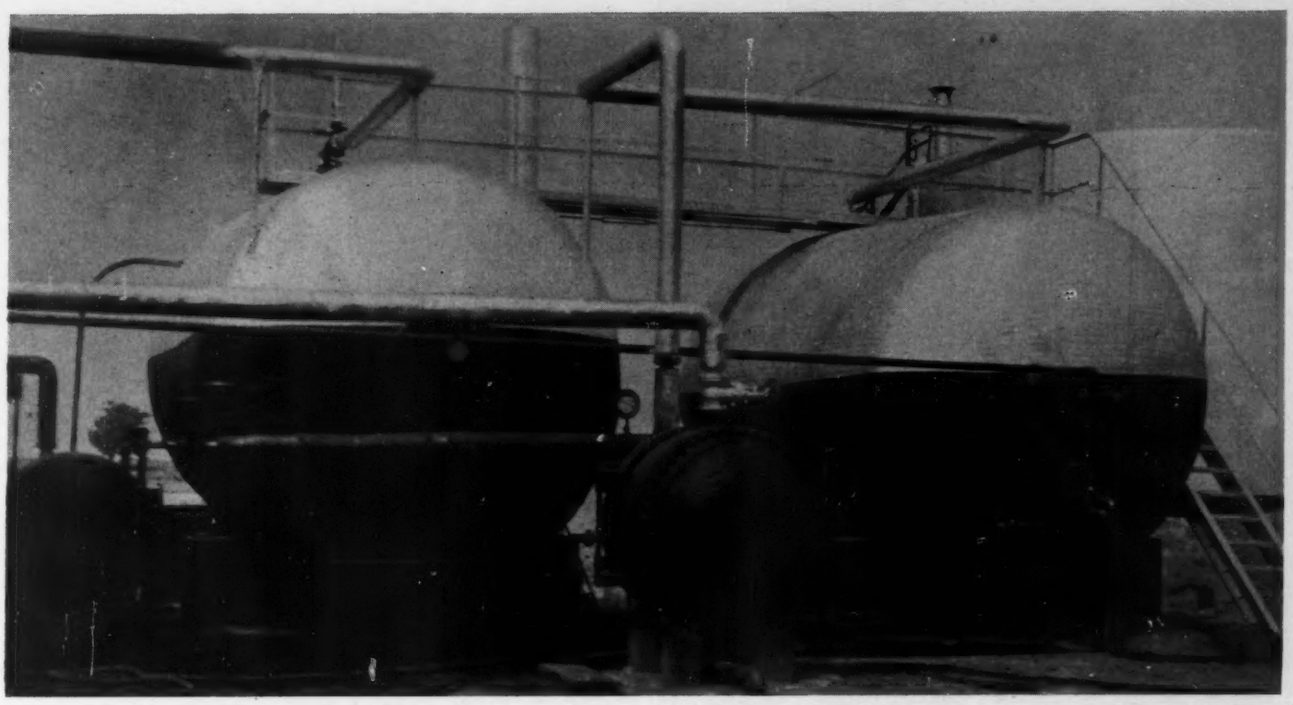
ditions improved oiliness may possibly be of benefit. It has been shown that under extremely high-speed operation, which tends to promote piston ring scuffing, the degree of scuffing may be lessened with an oiliness additive. Also, under low-temperature operating conditions, where the supply of lubricant immediately after starting may be somewhat inadequate, and where the products of combustion have remained on the cylinder wall for some period of time, it is perhaps possible that certain types of oiliness addition agents may act in such a way as to protect the surfaces from rusting and corrosion, and thus reduce the extent of wear which might otherwise be obtained. Under either of the operating conditions just mentioned, the advantages gained from the increased oiliness imparted by such additives appear to be very slight, and it is extremely difficult to demonstrate them clearly. This is probably because the mineral oils themselves possess good film strength, which is fairly adequate for the conditions encountered in the engine.

Except for one or two marketers who are adding compounds to their motor oils to improve oiliness, and a few others who are presumably incorporating antioxidants, which happen also to confer extra oiliness, the use of additives to obtain better lubrication properties has not been very extensive. Materials most frequently employed to increase oiliness and film strength contain groups commonly known as polar groups, such as those containing oxygen or phosphorus, or distinctly reactive chemical elements, such as sulfur or chlorine.

Among the oxygen-containing group, the following compounds are often employed: (a) naturally-occurring fatty or vegetable oils such as lard, neatsfoot, sperm, and castor oils; and (b) various synthetic esters such as those obtained from the acids produced by wax or oil oxidation.[55] Typical sulfur-containing compounds are sulfurized mineral and fatty oils, alkyl and aryl sulfides, and various thioethers.[56] Among the phosphorus compounds, alkyl and aryl phosphates and phosphites are representative.[57] Chlorinated esters of fatty acids and chlorinated aromatics are typical of the chlorine-containing materials being employed.[58] Of these, such commercially used agents as dibenzyl disulfide, sulfurized sperm oil, and amyl phenyl phosphite are also active bearing-corrosion preventives, whereas tricresyl phosphate and methyl dichlorostearate, etc., probably function almost solely to improve film strength.

Considerable attention has recently been called to "multifunctional" additives, which combine pour de-

[*Continued on page 87*]



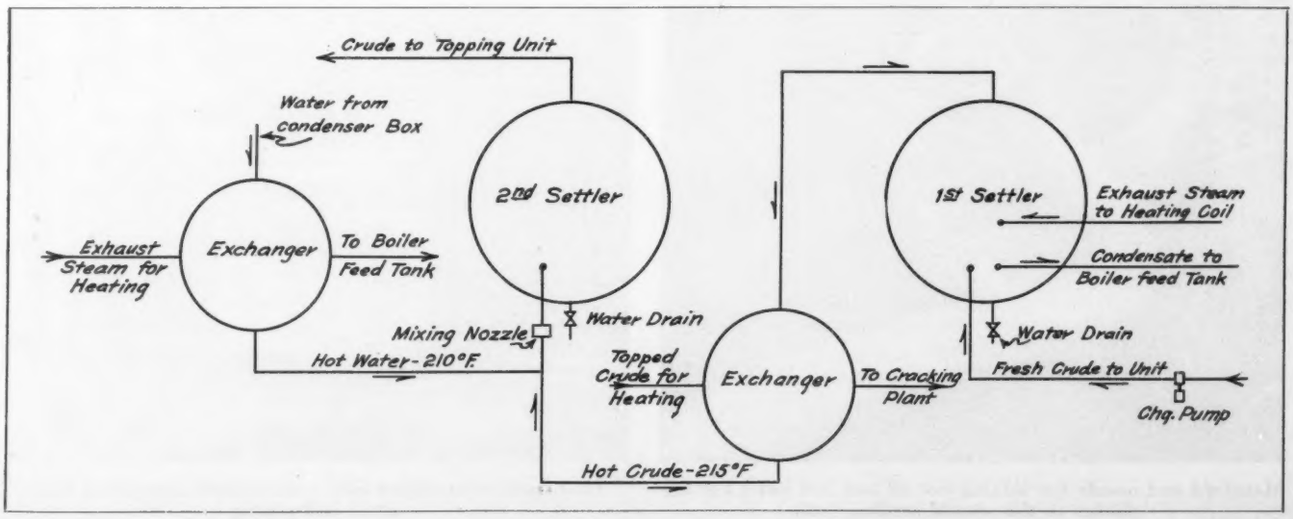
Settling tanks and piping arrangement for salt removal from crude oil at Malco Refineries, Inc., Artesia, New Mexico. The small vessel in the middle is the heat exchanger between the tanks. Here the crude charge is heated to 215° F. before being mixed with water at 210° F. for entry into the second tank.

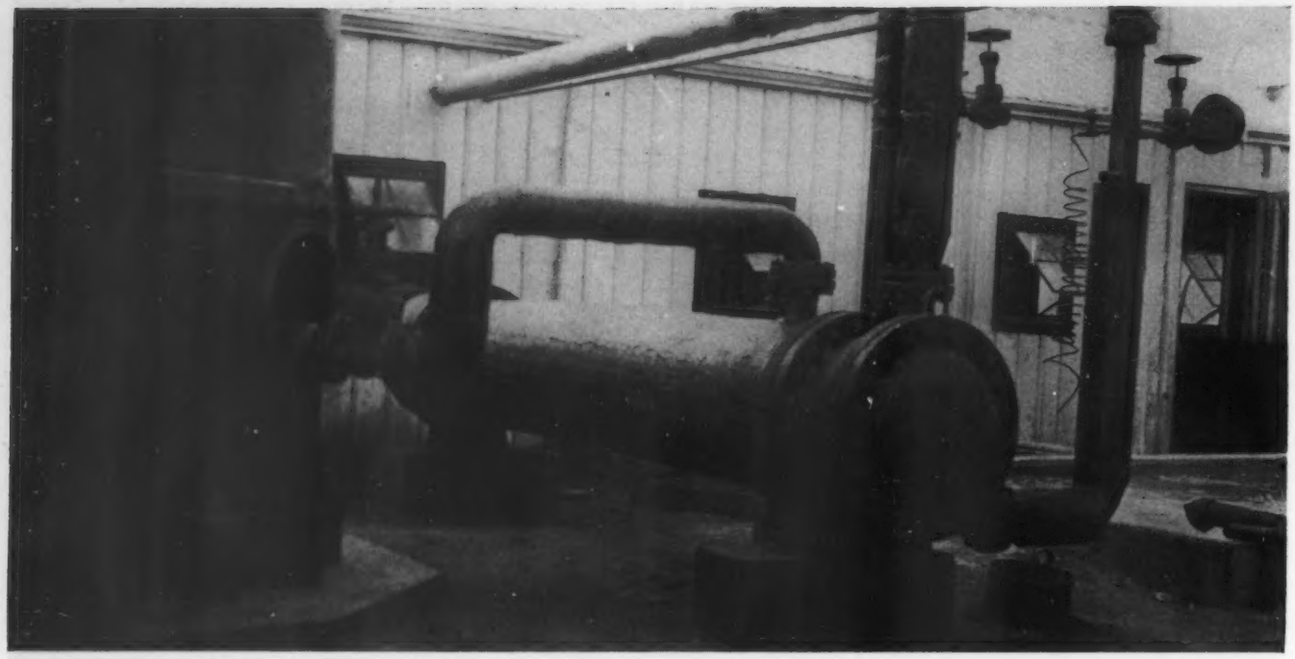
Water-Wash and Heat Reduce Salt Content 96 Percent

WATER-WASH, heat and settling have solved the problem of salt removal from crude oil for Malco Refineries, Inc., Artesia, New Mexico. Despite treating on leases in Eastern New Mexico, crude oil from the Mescalero sand area comes to the plant with as much as 150 pounds of salt per 1000 barrels in winter and 50 pounds per 1000 barrels in summer.

The process, adopted after limited success with previous methods, reduces the salt content to 4.5 pounds per 1000 barrels in winter and as low as 2.5 pounds per 1000 barrels in summer. In addition to salt removal, the treating process allows sand and other solids to settle out, a process which is stimulated since heat is a part of the process.

The treating plant consists of two horizontal settling tanks, three shell-and-tube heat exchangers.





After going through the salt removal unit, oil for the topping unit is preheated in exchange with residuum from the topping unit. This residuum does another heat transfer job between the two settling tanks before reaching the cracking unit.

a steam coil and a mixing nozzle. It functions ahead of the topping plant.

The first tank is equipped with a steam coil. The raw crude charge is pumped into this vessel, which is held at a predetermined level of wash water. Steam for the coil comes from pump exhaust, which is then recovered as condensate and returned to the boiler-feed tank. Oil is pumped into the base of the tank and contact with the water plus temperature increase allows salt removal as well as settling of solids, which are removed through water drain into the sewer system.

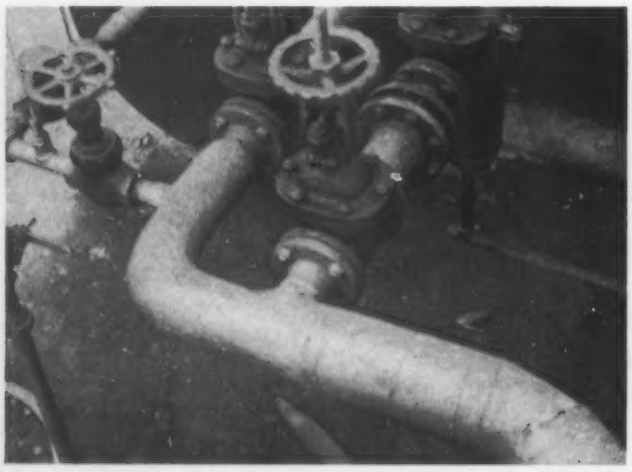
Crude passes out at the top of this settler and at the end opposite from the charge. Before entering the second tank, the oil is heated to 215° F. in exchange with oil in transit from the topping plant to the cracking unit. This oil does a previous heat transfer by exchange on the stream from the second settling tank.

Both oil and water enter the second settling tank through a manifold, equipped with a mixing device. This water is maintained at 210° F., coming from the main condenser box at some pre-heat and passing through an exchanger whose heat is from exhaust steam. Proportions of this turbulent mixture are 4 parts of oil to 1 of water. Pressure on the mixture is around 70 pounds.

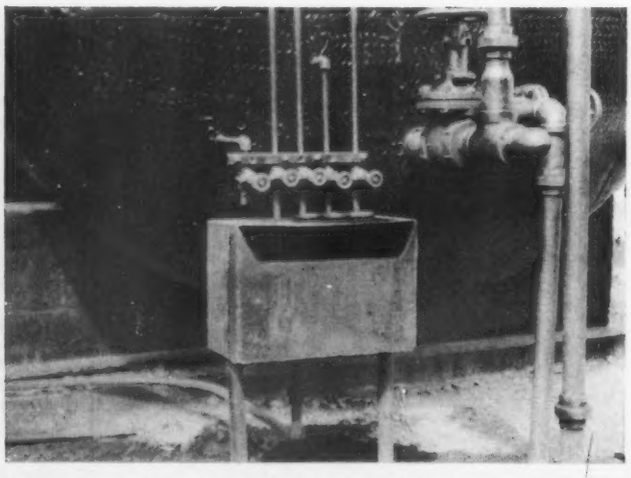
This second settling tank functions like the first, except that no steam coils are used. Salt-laden water drains off at the bottom while the charge to the topping plant passes overhead. More sand and other solids drain out in this tank.

Settling tanks, heat exchangers and piping are insulated. The vessels are set on concrete cradles.

Since the equipment was installed shutdowns have been less frequent and corrosion chargeable to salt has been negligible.



Manifold and nozzle for mixing hot oil and hot water for the charge to the second settling tank



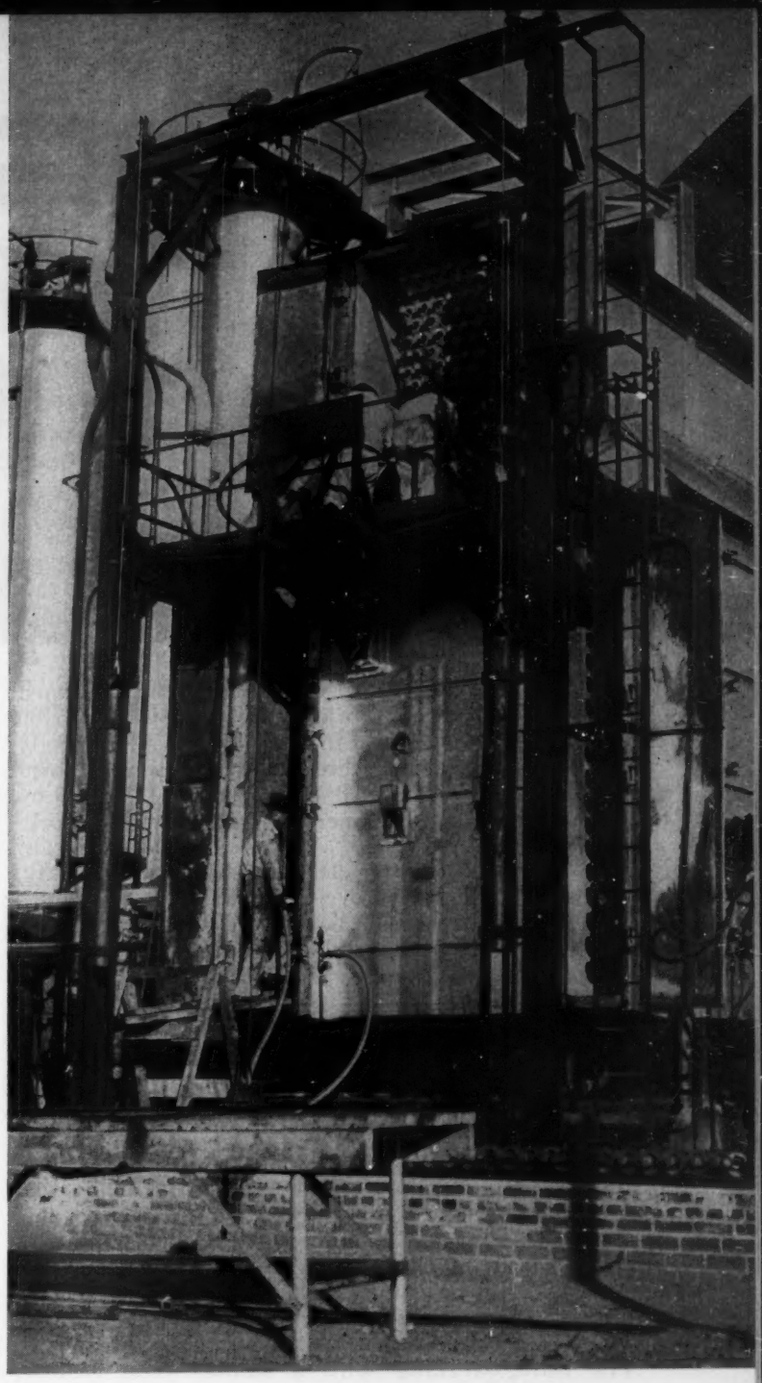
Each tank is equipped with a non-splash inspection box, valves and piping

Precise Plans Cut Clean-Out Period to Only 19 Hours

WHEN shipments keep so close to plant production that storage is but little above suction on the pumps, down time becomes a major issue in operations. This situation at the Wilmington, California, plant of Fletcher Oil Company prompted John Lynch, superintendent, to convert the clean-out period into an intensive activity in which each man had a definite part, while all equipment was brought up to standard in advance, then placed at the most advantageous spot for the working period.

Since the plant is only a year old, the first shut downs for cleanout and inspection required considerable replacement of gaskets and parts with the result that down time was excessive. With sufficient of this minor replacement made, Lynch decided to strive for a short cleanout period for December.

Preparations really began when the previous cleanout was completed. Before the equipment went back to the warehouse it was inspected and brought up to standard for the December period of downtime. Tube cleaning motors were cleaned, inspected and oiled. If steel cutters needed replacement new parts were added then. Sufficient gaskets, bolts, pump packing and the other equipment so frequently used during inspection was put in the warehouse stock. Air hose, wrenches and all other working tools were inspected before being racked.



For speed in U.O.P. cracking furnace tube cleaning two men run cutters through the convection bank, working downward, while a third starts at the bottom of the radiant bank on the soaking side and works upward. Another member of this crew fits thread protectors to each tube as protection against the cleaning rotors.

A Man Sized Job

From the experience of previous cleanouts, workmen had come to know their parts in the program. Since gaining a reduction in down time is a matter of men as well as equipment, the personnel was reminded of the necessity for getting the units back on stream with the result that the men were ready to strive for a record. The plan involved a definite job for each man, while the supervision required that man power be available in case the job should involve work not anticipated.

The day previous to the shutdown all tools and equipment had a second inspection. In the case of tools this involved checking to see that no device was missing and that use had impaired its efficiency. Next the equipment that might be needed for replacement was inspected. Studs, bolts and cap screws were brushed and nuts were run down on all threads to make sure that they would go into replacement service readily.

Another activity of the previous day was the placing of all tools at convenient points and the building of platforms, staging and flooring as needed. Water lines were laid to convenient outlets. The air compressor was inspected for volume and pressure sufficient for driving the tube-cleaning motors.

This preliminary activity resulted in all tools being in proper order and in the proper places. Likewise replacement equipment, anticipated for the task, was known to be in condition for quick installation. Each man knew his proper task.

Since the plant is near several residential areas,

Final cleaning of plugs is by wire brush and cloth. Previously encrusted material has been burned away with an acetylene torch. Each plug is numbered to assure replacement in the proper tube, a precaution against minor leaks.

the cleanout schedule was fixed to allow the most violent noise making work to be done between 7:30 in the morning and 7:30 in the evening. Accordingly the cracking-still fires were cut at 2:30 in the morning, while the grave-yard crew was on. Circulation was continued until temperature was down to working conditions.

By the time the early cleanout shift came on duty, it was possible to remove heads from the pressure vessels so water could be started through the reaction chamber and thus have it ready for removal of coke from the stainless steel lining.

Order in Tube Cleaning

First work on the cracking furnace was removal of the tube plugs. As these were removed they were numbered to correspond with the tube ends, after which the plugs were laid in order by numbers on planking on the fire wall around the furnace. As the plugs were laid on the fire wall, one man followed with an acetylene torch to burn off encrusted coke, so another workman could recondition each plug with a wire brush and cloth.

Furnace-tube cleaning was a three-man job. Two worked on a movable platform, beginning in the convection bank at the top and working downward. The third, working with a similar tube cleaner, started at the bottom tube of the radiant bank on the soaking side and worked upward.

A fourth tube-cleaning tool was used on the transfer line and associated piping.

No cutter wheel was used after teeth became dull. This was part of the speed program, since a dull cutter delays the cleaning process.

Another member of the tube-cleaning crew worked at the opposite end of the tube bank and placed thread protectors in each tube to prevent damage from the rotors.

Meanwhile other processing units had attention. Bubble-plate towers were washed down with cold water to remove sediment from trays. The plant mechanic overhauled the hot-oil pump, replacing packing and changing oil in the gear case. Another crew made connections on the water-cooled heat exchangers so solids could be dissolved by pumping a solution of hydrochloric acid through the system. Next this solution of acid, partly spent, was turned through the enclosed water-cooling system on the gas engines, which drive the water-circulating pumps. All these operations were completed prior to finishing the tube cleaning job.

Inspection went on simultaneously with cleaning. The plant manager and the foreman ran calipers on all tubes and passed on all replacements.

The work was done with speed but without haste. The plant was back on stream 19 hours after the fires were cut.

Equipment for heat exchange with water gets an internal bath of hydrochloric acid with the steam pump on duty. The diluted acid then does a cleaning job on the inclosed water cooling system for the gas engines.

Elements of Vaporization and Condensation

Part XI

Illustrative Exercises and Problems

R. L. HUNTINGTON, University of Oklahoma

A REVIEW of the ten previous papers of this series can best be made by solving several typical exercises which illustrate the principles set forth. A distinction is made between exercises and problems in that the exercise is far more simple than the problem, the latter being so complicated in nature that a number of simplifying assumptions usually are set up before even an attempt is made at the solution. A problem in the strict sense appears to be so involved at first sight that no solution can be obtained readily. Furthermore no two engineers, working independently, will come out with the same solution, in view of the wide variety of viewpoints and assumptions expressed by technical men. The problem method of instruction is often somewhat slow and painful but it is the soundest one for the engineering student to follow.

Differential Versus Equilibrium Flash Vaporization

In part 2 the author has briefly explained the nature of these two vaporization processes. Each process has its place to fill in the industrial plant, depending upon the particular situation at hand or the special product to be manufactured. The differential or batch method is one in which the evolved vapor is removed from the vessel as soon as it is formed, the temperature being raised continuously with a constant pressure or the pressure being lowered gradually at constant temperature. Other terms such as "unsteady state" or "non-flow" might also be used to describe this differential process.

The equilibrium flash vaporization is one in which all the evolved vapor is in close contact with its residual liquid at all times. The pipe still and flash chamber, operating under steady state flow conditions is the most common type of apparatus falling within this type of process. Although the pressure and temperature may vary from point to point in the equipment, the conditions at any one point remain constant from hour to hour.

A combination of these two processes is found in the conventional stage-separation method of recovering crude oil and distillates from oil and gas reservoirs. This method is differential in that the release of gas takes place at various pressure levels, however it is equilibrium flash in so far as the process follows the steady flow into and out of each separator in the system.

Piromov and Beiswenger [3] have simplified the determination of a flash vaporization curve for any typical crude oil establishing an empirical relationship between the true boiling point or differential vaporization and the "flash" vaporization curve. They found that over a large part of the distillation range, the "flash" yields a higher vaporization for the same temperature.

The difference between a batch and a continuous

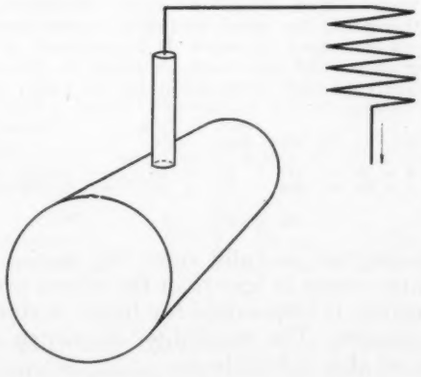


FIGURE 1 (A)
Differential vaporization

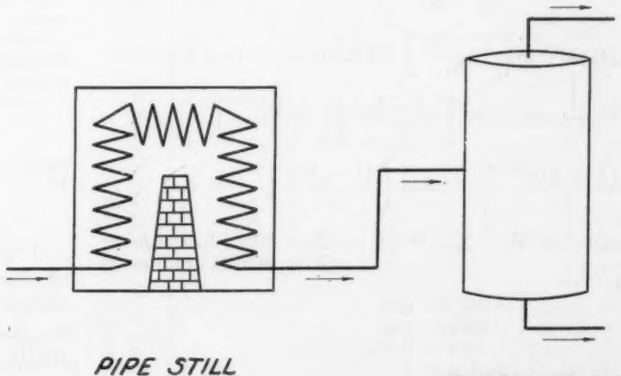


FIGURE 1 (B)
Flash vaporization

distillation can best be brought out by an illustration such as the following exercise:—

A mixture consisting of 40 mol percent propane and 60 mol percent normal butane is subjected to a batch distillation at a constant pressure of 100 pounds per square inch absolute until 50 mol percent of the blend is taken off as vapor overhead from the still.

(a) What will be the initial and final temperatures required to effect this batch operation? Figure 1(A).

(b) If the above mixture is heated in a pipe coil and "flashed" under equilibrium vaporization conditions in a vessel at a pressure of 100 pounds per square inch absolute. What temperature will be required in the vessel and its contents to bring about 50 mol percent vaporization? Figure 1(B).

Solution:

Part (a)

For this batch operation, a complete derivation of Rayleigh's equation is given in Walker, Lewis, and McAdams Principles of Chemical Engineering.[4] The initial temperature required to start vaporization (or the bubble point) is determined by the cut and try method and found to be approximately 95° F. The calculation is made on the basis of 100 mols of charge to the still. The term α is the relative volatility of propane to that of normal butane, or the ratio of their respective vapor pressures; L_1 and L_2 are the number of mols of feed and residue respectively. X_1 and X_2 are the corresponding mol fractions of propane in the feed and residue.

Part (a)

	Mol V.P.	Frac.	Partial pressure in liquid	
C_3 =	179	x .4 =	71.6	at 95° F.
C_4 =	50	x .6 =	30.0	
			101.6	

$$L_1 = 100 \quad L_2 = 50 \quad X_1 = .40 \quad X_2 = ?$$

$$\ln_e \frac{L_1}{L_2} = \frac{1}{\alpha - 1} \ln_e \left[\frac{X_1 \ (1 - X_2)}{X_2 \ (1 - X_1)}\right] + \ln_e \left[\frac{1 - X_2}{1 - X_1}\right]$$

$$\ln_e 2 = \frac{1}{2.52} \ln_e \left[\frac{0.4(1 - X_2)}{X_2(0.6)}\right] + \ln_e \frac{(1 - X_2)}{0.6}$$

$$2.52 \ln 2 = \ln_e 0.667 \left[\frac{1 - X_2}{X_2}\right] + 2.52 \ln \left[\frac{(1 - X_2)}{0.6}\right]$$

$$2.52 \ln 2 = \ln_e 0.667 + \ln \left[\frac{1 - X_2}{X_2}\right] + 2.52 \ln(1 - X_2) - 2.52 \ln(0.6)$$

$$1.75 + 0.406 = \ln \left[\frac{(1 - X_2) \ (1 - X_2)^{2.52}}{X_2}\right] =$$

$$\ln \left[\frac{(1 - X_2)^{3.52}}{X_2}\right] = 0.864 \left[\frac{(1 - X_2)}{X_2}\right]^{3.52} = 2.37$$

Final Temp. = 116°F. $X_2 = 0.195$ or $X_3 = .195$ (C_3 in liquid)
$X_4 = .805$ (C_4 in liquid)

Part (b)

$$100y_3 = p_3x_3$$
$$100y_4 = p_4x_4$$
$$0.4 = 0.5x_3 + 0.5y_3$$
$$x_3 + x_4 = 1$$
$$y_3 + y_4 = 1$$

$$p_3 = \frac{100y_3}{x_3} \qquad p_4 = \frac{100y_4}{x_4} \qquad \frac{p_3}{p_4} = 3.46 = \frac{y_2x_4}{y_4x_3} = \alpha$$

$$3.46 = \frac{x_4(1 - y_4)}{y_4(1 - x_4)} \qquad y_4 = \frac{0.6 - 0.5x_4}{0.5} = 1.2 - x_4$$

$$3.46 = \frac{x_4(1 - 1.2 + x_4)}{(1 - x_4)\ (1.2 - x_4)} = \frac{0.2x_4 + x_4^2}{1.2 - 2.2x_4 + x_4^2}$$

$$4.15 - 7.61x_4 + 3.46x_4^2 = 0.2x_4 + x_4^2$$

$$2.46x_4^2 - 7.41x_4 + 4.15 = 0 \qquad x_4^2 - 3.01x_4 + 1.685 = 0$$

$$x_4 = 3.01 \pm (9.06 - 6.15)^{1/2} = \frac{3.01 - 1.52}{2} = .745$$

$p_3 = 214$ $\quad t_3 = 108°$
$p_4 = 61$ $\quad t_4 = 108°$

The Physical State of a System

The phase rule is a very useful generalization when one wishes to determine the physical state of certain materials confined in a vessel under a fixed temperature and pressure.

The following set of exercises are suggested as a test of one's ability to determine the state of a system.

In each of the following cases, determine the physical state of the chemical compounds present in a cylinder equipped with a frictionless piston and if possible the mol fraction of each compound in each phase. State any simplifying assumptions you may see fit to make, giving your reason for doing so.

(a) 2 pounds each of water and air at 212° F and 16 pounds per square inch absolute.

(b) 2 pounds each of water and air at 212° F. and 40 pounds per square inch absolute.

(c) 1 pound mol each of normal butane and normal pentane at 100° F and 50 pounds per square inch absolute.

(d) One pound mol each of NC_4 and NC_5 at 100° F. and 20 pounds per square inch absolute.

(e) A mixture of NC_4 and NC_5 at 100° F. and 28 pounds per square inch absolute.

(f) What is the dew point of a mixture consisting of 1 pound of steam and 3 pounds of NC_5 vapor. The pressure is to be held constant at 10 pounds per square inch absolute? What is the composition of the first drop of condensate? What is the bubble point for the water-pentane mixture? At what temperature will pentane start to condense?

Solution:

(a) It is easily seen that some vaporization will take place since air under these conditions is so slightly soluble in water; furthermore, the water is under a total pressure only a little above its vapor pressure. It is assumed at first that the mixture is totally vaporized, in order to determine the partial pressure of each component in the vapor phase.

	Lbs.		Lb. Mols.	Mol. Frac.		Total Pr.		Partial Pressure In Vapor
Water	2 ÷ 18	=	.111	.62	x	16	=	9.9 lbs./sq. in. abs.
Air	1 ÷ 29	=	.069	.38	x	16	=	6.1 lbs./sq. in. abs.
			.180	1.00				16.0

The assumption is valid since the partial pressure of the water vapor is less than the vapor pressure of water, making it impossible for liquid water to exist in the cylinder. The solubility of air in water is neglected in this calculation.

	Lbs.	Mols.	Mol. Frac.		Total Pr.		Partial Pressure
Water	2	.111	.62	x	40	=	24.8 lbs./sq. in. abs.
Air	2	.069	.38	x	40	=	15.2 lbs./sq. in. abs.

The assumption is made again that the cylinder is filled with vapor only. Since this gives a partial pressure of 24.8 pounds per square inch absolute for the water vapor, it is easily seen that such a condition cannot exist as the vapor pressure of water is only 14.7 pounds per square inch absolute. Therefore two phases must exist. The partial pressure of water vapor is necessarily the same as the vapor pressure

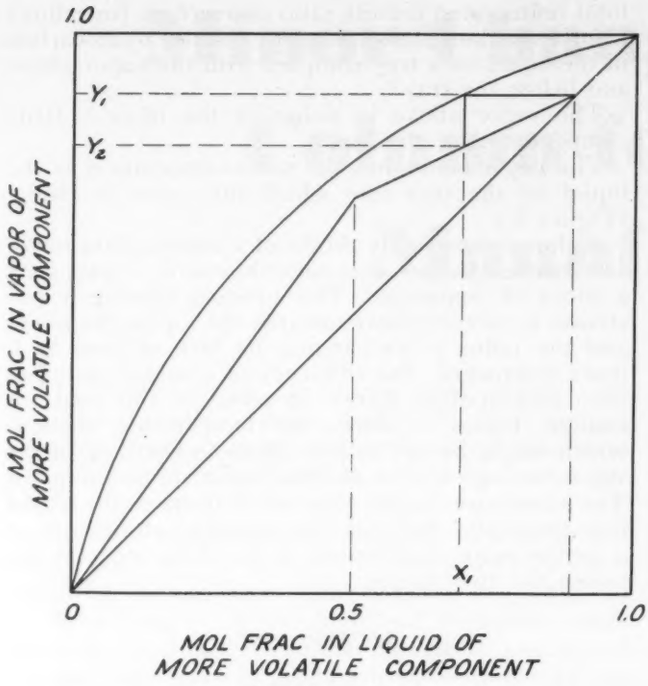


FIGURE 2

Fractionation of a Binary Mixture in an actual tower. (Comparison of liquid and vapor composition around a plate.)

of the liquid water. The vapor above the water consists of:

	Partial Pressure	Vol. or Mol. Fraction
Water vapor	14.7 lbs./sq. in.	.367
Air	25.3 lbs./sq. in.	.633
		1.000

If the total pressure in the cylinder is greater than the vapor pressure of the mixture, the two hydrocarbons would be in liquid form.

	Vapor pressure		Mol frac. in liquid		Partial pressure
Normal butane	53	x	.5	=	26.5
Normal pentane	16	x	.5	=	8.0
					34.5 total vapor pressure

The mixture would therefore be in liquid form.

(d)

It is assumed that the mixture is all vapor.

By Raoults Law:

	π	$y = p\ x$	
N butane	20	$.5 = 53\ x_4$	$x_4 = .188$
N pentane	20	$.5 = 16\ x_5$	$x_5 = .625$
			.813

It is readily seen that it will take a higher pressure to start condensation, therefore the above assumption is valid.

The dew point can be determined by trial and error.

Assume the total pressure = 25 lb.			
N butane	$25 \times .5 = 53\ x_4$	$x_4 =$	.236
N pentane	$25 \times .5 = 16\ x_5$	$x_5 =$	.780
			1.016

Assume the total pressure = 24 lb.			
N butane	$24 \times .5 = 53\ x_4$	$x_4 =$	.226
N pentane	$24 \times .5 = 16\ x_5$	$x_5 =$	.750
			.976

The dew point is approximately 24.5 pounds per square inch absolute.

(e) Since 28 pounds pressure is between the 24.5 pounds dew point and 34.5 pounds bubble point, the mixture must be part vapor and part liquid. The composition of each phase can be determined as follows:

		π	$y = p$	x
(1)	N butane	28	$y_4 = 53$	x_4
(2)	N pentane	28	$y_5 = 16$	x_5
(3)	N pentane	$28(1-y_4) = 16(1-x_4)$		

Adding (1) and (3)

$$28 = 16 + 37\ x_4$$

Liquid = $x_4 = .324$ (N butane), $x_5 = .676$ (N pentane), 1.000

Vapor = $y_4 = .614$ (N butane), $y_5 = .386$ (N pentane), 1.000

(f)

The dew point for two components which are immiscible in the liquid state cannot be determined by Raoult's law, since each component exerts its own vapor pressure independent of the other.

	lbs.	lb/mol = lb mols	mol frac	Total Pr		Partial pressure
Water	1	÷ 18 = .0555	.57	× 10	=	5.7
N pentane	3	÷ 72 = .0417	.43	× 10	=	4.3
		.0972	1.00			

Referring to a standard set of steam tables, it is found that water has a vapor pressure of 5.7 pounds at 168° F. The first drop of condensate will therefore be water.

The bubble point or vapor pressure of the mixture will be the temperature at which the sum of the vapor pressures will equal 10 pounds per square inch absolute. By trial and error, this temperature is found to be 75° F. (approximately).

	vapor pressure
Water =	0.43 lbs./sq. in. abs.
N pentane =	9.57 lbs./sq. in. abs.
	10.00

As the temperature is lowered below 168° F., steam continues to condense out of the vapor, causing the

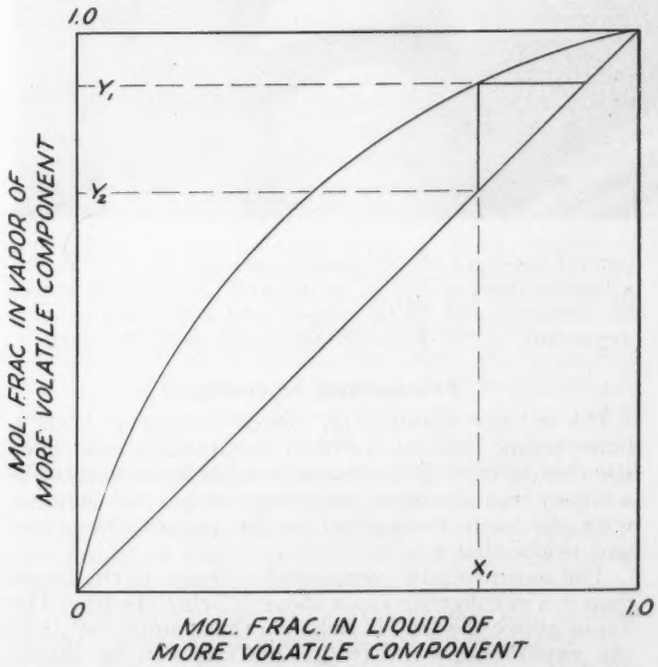
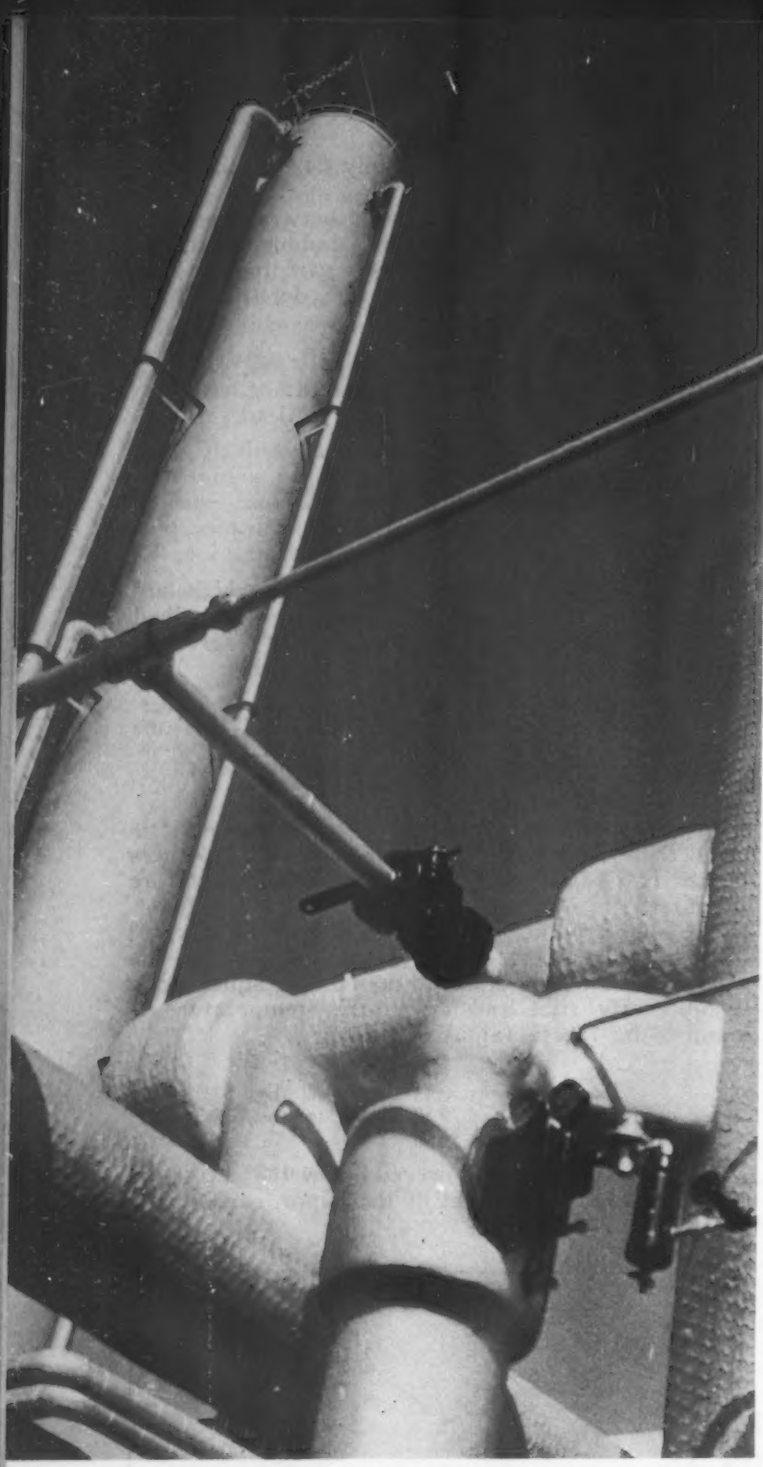


FIGURE 3

Fractionation of a Binary Mixture with total reflux. Vapor and liquid compositions around a plate.



partial pressure of the normal pentane to rise. When a temperature of 75° F. is reached the pentane starts to condense, out of the vapor, and continues to condense out, at 75° F. until the bubble point is reached.

Fractionator Operation

(1) In any commercial tower operating with a finite reflux ratio of overflow to product, how does the composition of the more volatile hydrocarbon in a binary liquid mixture on a tray compare in richness with the same component in the vapor both above and below that tray?

The more volatile component is leaner in the liquid than it is in either the vapor above or below the tray. The vapor above the tray is richer in that component than the vapor below the tray. This fact can be shown (Figure 2) graphically by reference to a small section of the tower either above or below the feed plate.

(2) In any adiabatic fractionator operating with total reflux or an infinite ratio of overflow (or reflux) to product, how does the more volatile hydrocarbon in the liquid on a tray compare with the vapor above and below the tray?

The vapor above is richer in the more volatile component than the liquid.

The vapor below has the same composition as the liquid on the tray into which the vapor is rising. (Figure 3.)

Although one rarely thinks of a bubble-plate tower as a heat exchanger, it is nevertheless, in a way, such a piece of apparatus. The upward flowing vapor stream is carrying heat towards the top of the tower and the reflux is exchanging its lack of heat as it flows downward. The efficiency of a bubble plate has been measured by Carey[1] in terms of this heat exchange. Figure 4 shows the temperature changes which might be apt to take place in the flow of the vapor through a plate and the liquid across the plate. The resistance to the flow of heat from the vapor into the liquid prevents the complete attainment of a temperature equilibrium in the finite contact between the two phases.

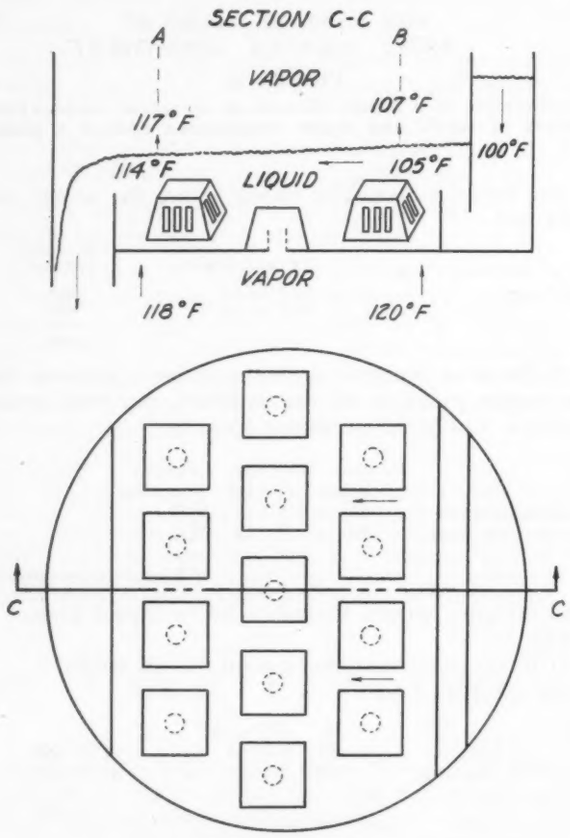


FIGURE 4
The fractionator as a heat exchanger. (Temperature relationships between vapor and liquid.)

In a total reflux tower or one in which equilibrium is attained on each tray, the vapor will emerge at the same temperature as the liquid from which it is rising.

LITERATURE CITED

[1] Carey, J. C., Perry's Chemical Engineers Handbook, p. 1191, McGraw-Hill Book Company, New York City, 1934.
[2] Huntington, R. L., Part (IV) This series in Refr. and Nat. Gaso. Mfr. May, 1940.
[3] Piromov and Beiswenger, Equilibrium Vaporization of Oils, A.P.I. Bull. 10, No. 252, 1929.
[4] Walker, Lewis and McAdams, Principles of Chemical Engineering, McGraw-Hill Book Company, New York.

Minor Changes Prepare Column for Butane Manufacture

BECAUSE of an increasing local demand for liquefied petroleum gases Deep Oil Development Company has converted its fractionating column in the gasoline plant in the K-M-A field for production of these fractions. When the plant was constructed, in conjunction with a repressuring project, the principal function of the equipment, particularly the fractionating column, was stabilizing the raw gasoline.

The column is 74 feet high and 30 inches, inside diameter, equipped with the regulation number of fractionating trays to produce a base product of any required vapor pressure, and a single cut from the overhead outlet that included any fractions not required for the major fraction below. The column was equipped for reflux return, condensing the necessary amount of overhead vapors for liquid return, and allowing that portion not required, to vaporize through reducing valves and return to repressuring compressors for re-introduction into the sand.

The raw natural gasoline is manufactured by compressing the field gas in two stages, with intercoolers between the cylinders of the engines. The raw material contains as many of the fractions as is practical to condense in this process, with the composite blend of low and high condensate pumped to the column. The column has a shell-and-tube reboiler whose flow and volume are controlled by instruments operating precision valves on the steam piping at the entrance to the unit.

Under average operating conditions, the quantity of raw gasoline pumped to the column is 6 gallons per minute, introduced into the column through a nozzle near the mid-section. The temperature of the reboiler is maintained at 310° F. for all stages of operation, when taking a side cut of butane, or raising the vapor pressure of the bottom cut above 14 pounds. The overhead fractions, including propane and lighter, are condensed in shell-and-tube, horizontal units, cooled with water, with the condensate accumulating in a drum directly beneath these condensers. The quantity of condensate is not measured into this vessel, but a flow-controlling instrument permits a close clearance pump to return 6¾ gallons per minute to the top of the fractionating column. This amount maintains a top temperature on the column at 150° F. Pressures on the tower are held constant by instrument control at 200 pounds, gauge.

When the plant was first placed in operation, a long, horizontal tank was installed near the column to receive the overhead condensate from the reflux accumulator as the material flowed through a liquid level controlling apparatus so there would be sufficient material to operate the column. This was held in reserve in the larger vessel instead of depending upon the small quantity contained in the reflux accumulator. After the demand for butane increased, attempts were made to fractionate a cut from the column which would be desirable for this purpose.

The second, fourth, sixth and eighth trays from the top of the column were equipped with draw-off nipples for testing purposes. It was thought that a side cut could be withdrawn from the column, taking it from the second plate from the top. The product was too high in propane content, and the bottom product contained larger amounts of the butanes than necessary for a given vapor pressure. The liquid line was changed to the fourth plate and connected to the horizontal vessel, formerly used as a surge tank from reflux. The column was adjusted to the above temperature, charge, reflux and pressure conditions, and the side cut taken from the column was satisfactory for fuel in drilling engines.

Obviously, at 6 gallons per minute of raw product to the column, this gasoline plant produces only about 8500 gallons per day, and to remove the required volume of butane from the column does not necessitate a large capacity line. A ⅜-inch copper line is used as the liquid pipe from the fourth plate sample draw-off connection, which has carried as high as 1,500 gallons of butane per day. The adjustment of the needle valves controlling the amount of butane prevents uncondensed vapors from flowing from the column into the butane vessel, which could throw the column out of adjustment. The normal operation of the column, with a fixed volume of raw charge, is not changed materially during the day, and it is seldom necessary to change the setting of the needle valves controlling the flow of butane.

The overhead product, containing the undesired fractions of propane and lower-boiling hydrocarbons, condense and accumulate in the reflux drum, and is piped to various parts of the plant, and to a near-by oil treating plant to reduce temperatures of different operations. After expanding into the cooling exchangers, the vapors may, or may not be returned to the intake of the engine-driven compressors for recycling, but under all conditions, a sufficient level is maintained in the reflux accumulator that control of the fractionating column is not interrupted.

The butane has a boiling range from —5° F. to 30° F., which, when used for fuel in internal combustion engines, is considered entirely satisfactory.

Hydrogen Content As a Basis for Correlating the Specific Heat of Liquid Hydrocarbons and Petroleum Fractions

JOHN GRISWOLD and H. A. ALVES*
The University of Texas, Austin, Texas

FROM the assumption that the molecular heat capacity of a liquid hydrocarbon is the sum of the atomic heat capacities of its carbon and hydrogen atoms, a linear relation between specific heat at 32° F. and the weight percent hydrogen results applicable to petroleum. The correlation is good between normal paraffin and aromatic hydrocarbons but not for napthenes and olefines by this procedure.

Specific-heat data on petroleum fractions for which the hydrogen content could be estimated are obtained from the literature. These and experimental values correlate very nearly as closely as by the best equations hitherto developed, by the equation:

$$(C_p)32°F = 0.0152\ (\text{Wt. \%H}) + 0.2448$$

A number of empirical correlations of the specific heats of liquid petroleum fractions have appeared within recent years. Early equations were developed from data on limited types of stocks, i.e., crudes or gas oils, by considering specific gravity at 60° F. to be the only variable besides temperature. Since molecular structure is also involved, these equations are not of general applicability.

K. M. Watson's discovery and development of the "Characterization Factor," K,[9, 11, 12] which depends principally upon molecular structure enabled him to obtain a general specific heat correlation. A convenient chart of his results for petroleum fractions has been presented, but the equation

$$C_p = [0.6811 - 0.308S + t(0.000815 - 0.000306S)]\ (0.055K + 0.35) \qquad (1)$$

is somewhat tedious to use when many calculations are to be made upon a variety of different stocks. Gaucher[4] in seeking a more compact relation, reviewed existing data and correlations and recommended the following equation in terms of specific gravity and A.S.T.M. 50 percent distillation temperature (in °R):

$$C_p = 0.6230 - 0.0187\left(\frac{T^{0.5}}{S^{1.5}}\right) + 0.000355\left(\frac{T}{S^2}\right) + 0.00045(t-32)/S \qquad (2)$$

Equation 2 avoids evaluating K, and is more rapid of application when the distillation test is available.

Equations 1 and 2 are of comparable accuracy, and a simpler yet general equation would be useful. One has been developed as follows: Assume molecular heat capacity MC_p of any liquid hydrocarbon of molecular weight M to be the sum of the constant atomic heat capacities of carbon and hydrogen atoms; c_c and c_h respectively.

Let H' = wt. fraction of hydrogen in molecule
Then, $(1 - H')$ = wt. fraction of carbon in molecule
and $M(1 - H')/12$ = the number of carbon atoms
$MH'/1$ = the number of hydrogen atoms.

The general formula of the hydrocarbon is:

$$C_M(1 - H')/12M(MH')$$

The molal heat capacity is the number of carbon and hydrogen atoms multiplied by their respective heat capacities:

$$MC_p = (c_c)M(1 - H')/12 + (c_h)(MH')$$

Dividing through by M and rearranging:

$$C_p = (c_h - c_c/12)(H') + c_c/12$$

which may be represented at constant temperature as

$$(C_p)_t = aH + b \qquad (3)$$

Specific heat at constant temperature is evidently

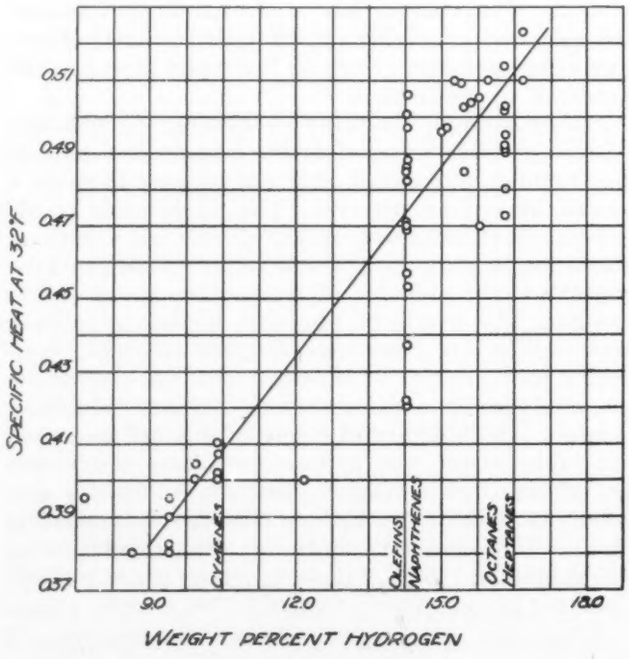


FIGURE 1

Plot of specific heat versus weight percent hydrogen for pure liquid hydrocarbons.

*Present address: The Pure Oil Company, Winnetka, Illinois.

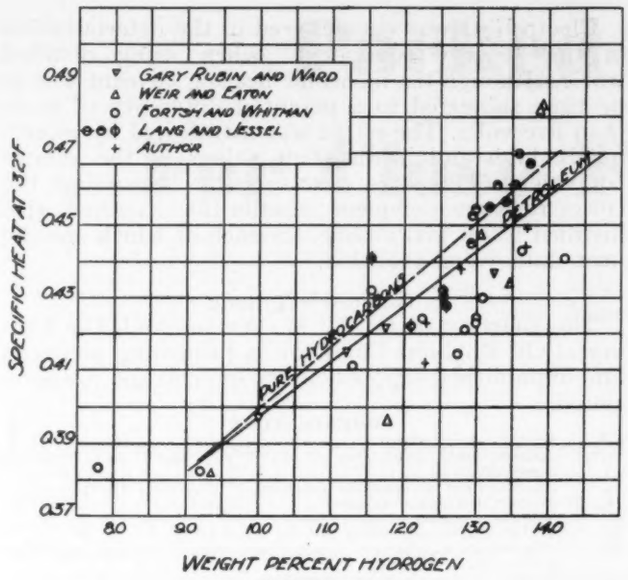


FIGURE 2

Plot of specific heat versus weight percent hydrogen for liquid petroleum fractions.

linear with weight percent hydrogen if the stated assumptions hold.

Available specific heat data on pure liquid hydrocarbons[4, 8] are plotted against hydrogen content in Figure 1. For normal paraffins and aromatics, the correlation is excellent; for iso-paraffins, it is only fair; and for naphthenes and olefins, it is unsatisfactory; points for the last classes of compounds scattering about equally on either side of the line. Since all but the light petroleum fractions contain innumerable individual components, it is to be expected that component deviations should largely counterbalance for oils. That this is actually the case is evident from Figure 2; a plot of petroleum specific heat data from the literature, corrected to 32° F. by temperature coefficients derived from the respective authors' data or correlations. Hydrogen contents were calculated by the method presented later in this article. Two sets of otherwise usable data were omitted from Figure 2; those of Henderson, Ferris, and McIlvain,[5] and Leslie and Geniesse.[7] In these two articles the experimental data covered insufficient range, particularly at low temperatures, to give a reliable extrapolation to 32° F. The equation of the solid line obtained by the method of least squares from the data points of Figure 2 is:

$$(C_p)_{32\ deg\ F} = 0.0152(\text{Weight \% H}) + 0.2448 \qquad (3)$$

A comparison of equations 1 and 3 by the data from which the hydrogen content could be estimated is presented in Table 1.

TABLE 1

Reference No.	No. Points	Ave. % Eq. 1	Deviation Eq. 3	Max. % Eq. 1	Deviation† Eq. 3
Author	5	2.5	2.0	3.6	4.7
2	12	3.2	3.4	12.3	5.4
3	4	2.3	0.7	4.1	2.0
5*	10	4.5	8.3	9.6	12.6
6	15	2.2	2.5	5.9	5.2
7*	6	15.9	19.6	19.7	24.0
13	7	1.6	3.5	3.8	6.6

* Omitted from Figure 2.
† Numerical average of deviations without regard to sign.

Temperature Coefficient of Specific Heat

Specific heat is linear with temperature in all correlations. This is fortunate since (dC_p/dt) is then independent of temperature level and for any change in heat content, $(C_p)_{av.}$ occurs at the arithmetic average temperature. A temperature coefficient of specific heat applicable above 32° F. is obtained by differentiating Equation 1:

$$dC_p/dt = (0.055K + 0.35)(0.000815 - 0.000306S) \qquad (4)$$

A simpler temperature coefficient results from Equation 2:

$$dC_p/dt = 0.00045/S \qquad (5)$$

Equations 4 and 5 do not appear compatible, although they give concordant results for most stocks under ordinary conditions. Other correlations involve specific gravity in the same manner as does Equation 1. However, more precise data must be at hand before this point can be cleared up with certainty. Specific heat at any temperature is given by the relation;

$$(C_p)_t = (C_p)_{32\ deg\ F} + \int_{32}^{t} (dC_p/dt)dt$$

Combining with Equation 4 and integrating, considering (dC_p/dt) as a constant;

$$(C_p)_t = (C_p)_{32\ deg\ F} + (0.055K + 0.35)(0.000815 - 0.000306S)(t - 32) \qquad (6)$$

Finally, the relation for the change in heat content is;

$$Q = (W)(C_p)_{t_{av.}}(t_2 - t_1) \qquad (7)$$

Estimation of Hydrogen Content

Hydrogen content is not a routine test for petroleum fractions in the same sense as is gravity, and might seem to limit the usefulness of Equation 3. However, Sweeney and Voorhees[10] correlated hydrogen content with average boiling point and gravity. More recently, Watson related hydrogen content to his Characterization Factor, giving a very good approximation from gravity and any other molecular average property of the oil such as distillation or viscosity. Watson's correlation was used to obtain hydrogen content data of oil data from the literature. Later unpublished information furnished by Watson is approximated by the equation

$$\text{Wt. \%H} = 14.3 + 0.175(°\text{A.P.I.}) - 7500/T_m \qquad (8)$$

T_m is the *mean average* boiling point.[9] The numerical average deviation of values calculated by Equation 8 from our experimental specific heats is 1.9 percent, and the data of Figure 2 are believed to be closely in line with this figure.

Experimental

Specific heat data were obtained upon five petroleum stocks by the calorimetric method of Bailey and Edwards.[1] The one-quart Thermos bottle calorimeter was immersed in an ice-water bath to reduce radiation to the system. A thermometer of the Beckman type was used for temperature differential measurements. The hydrogen contents of the oils investigated were determined by an oxygen bomb combustion method similar to that of Whitaker.[14] In this method, a sample of the oil is fired in a lead-lined oxygen bomb and the water formed on combustion is absorbed from the combustion gases and determined gravimetrically.

Table 2 shows the A.S.T.M. inspection tests on the

five samples studied. The results of the investigations are presented in Table 3.

TABLE 2

STOCK	A.P.I. Gravity	Viscosity S.U./100 °F.	A. S. T. M. DISTILLATION, °F.								
			10%	20%	30%	40%	50%	60%	70%	80%	90%
Naphtha..	48.6	....	329	335	339	342	345	349	354	359	367
Kerosene..	43.5	....	382	392	402	412	422	432	444	459	478
Gas Oil....	24.2	86.6									
Lube No. 1	25.4	357.0									
Lube No. 2	30.6	250.0									

Discussion of Calorimetric Technique

Two items in the specific-heat determination are noteworthy. A constant-speed stirrer had to be placed in a wide-mouth quart Thermos bottle. Paddles of several designs were used, consisting of a small bent brass plate mounted on a thermally-insulated brass shaft. In all cases it was found that a single plate cut and bent in the shape of a propellor provided better mixing than several plates of any shape when mounted one above anotl er on the shaft: The latter arrangement produced a simple swirling motion which did not quickly mix the upper and lower portions of liquid.

TABLE 3

STOCK	Specific Heat at 32 °F.		Wt. % Hydrogen Experimental	% Deviation of Eq. 3*
	Experimental	Eq. 3		
Naphtha.....	0.444	0.453	13.7	2.03
Kerosene.....	0.449	0.453	13.7	0.93
Gas Oil.....	0.423	0.431	12.3	2.00
Lube No. 1.....	0.438	0.439	12.8	0.23
Lube No. 2.....	0.412	0.432	12.3	4.70

* Using calculated % hydrogen.

Electrolysis was encountered in the determination of the "energy equivalent" when using distilled water, although the nichrome heating element was at no time subjected to a potential difference of more than five volts. The effect was manifested by inordinately high and inconsistent values of the energy equivalent. This was overcome by lacquering the entire resistance element; results then checked with distilled water and aniline, for each of which specific heat data were available.

Acknowledgment

The courtesy of Dr. K. M. Watson and The Universal Oil Products Company in furnishing preprints and unpublished supplementary information is appreciated.

NOMENCLATURE

a,b	Empirical Constants.
c_c,c_h	Atomic heat capacities at 32°F of carbon and hydrogen respectively.
C_p	Specific heat at constant pressure, B.T.U./(lb.) (F.°)
H	Weight Percent hydrogen.
H′	Weight fraction of hydrogen
K	U.O.P. Characterization Factor, $(T_b)^{1/3}/S$.
M	Molecular weight for pure compounds, average molecular weight for mixtures.
Q	Change in heat content, B.T.U.
S	Specific gravity, 60°F/60°F.
t	Temperature, °F.
T	Temperature, °Rankine.
W	Weight of oil, lbs.

LITERATURE CITED

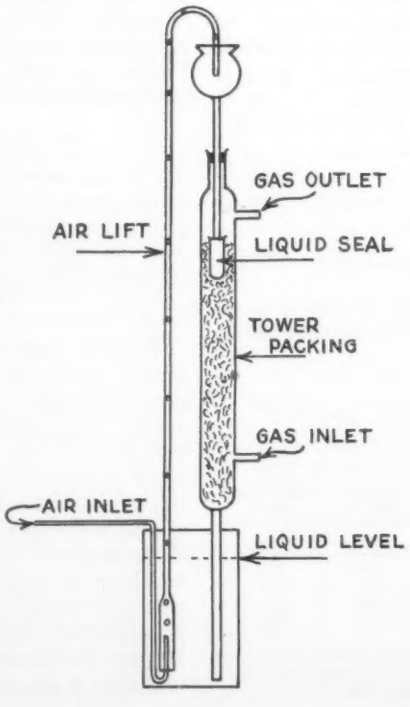
[1] Bailey and Edwards, *Ind. Eng. Chem.*, **12,** 892 (1920).
[2] Fortsh and Whitman, *ibid,* **18,** 795 (1926).
[3] Gary, Rubin, and Ward, *ibid,* **25,** 178 (1933).
[4] Gaucher, *ibid,* **27,** 57 (1935).
[5] Henderson, Ferris, and McIlvain, *Ind. Eng. Chem., Anal. Ed.,* **1,** 148 (1929).
[6] Lang and Jessel, *J. Inst. Petroleum Tech.,* **16,** 476, 783 (1930); **17,** 572 (1931); **18,** 850 (1932).
[7] Leslie and Geniesse, *Ind. Eng. Chem.,* **16,** 582 (1924).
[8] Parks, Huffman, et al., *J. Am. Chem. Soc.* **52,** 1032, 1547, 3241, 4381 (1930); **53,** 3876 (1931).
[9] Smith and Watson, *Ind. Eng. Chem.,* **29,** 1408 (1937).
[10] Sweeney and Voorhees, *ibid,* **26,** 197 (1934).
[11] Watson and Nelson, *ibid,* **25,** 880 (1933).
[12] Watson, Nelson and Murphy, *ibid,* **27,** 1460 (1935).
[13] Weir and Eaton, *ibid,* **24,** 211 (1932).
[14] Whitaker, *Fuel in Science and Practice,* **7,** 63 (1928).

Gas Washing Apparatus Built of Laboratory Glassware

THE gas washing apparatus illustrated here was built from common laboratory glassware and has functioned with entire satisfaction.

The tower consists of a common condenser jacket 40 centimeters long and 3 centimeters in diameter. This jacket is packed with glass beads or short pieces of glass tubing. The packing is held by placing a few longer pieces of glass tubing at the bottom of the condenser jacket. The tower is mounted vertically so that one end extends down into a wide-mouth bottle carrying the required volume of concentrated sulphuric acid. It may be necessary in some instances, to attach a piece of glass tubing to the lower end of the condenser jacket in case this portion is not long enough to extend far enough into the acid to prevent the gas from leaking.

The top of the tower is fitted with a thistle tube receiver with a fairly long stem. The stem extended downward into a small test tube. The thistle tube is held in place by means of rubber stopper and the small test tube by the packing material in the tower. The thistle tube extends sufficiently far into the test tube to allow the acid in the tube to form a liquid seal which prevents escape of the gas.



The water connections of the connections of the condenser jacket serves as the inlet and outlet gas connections. The gas may pass either upward or downward through the tower.

A continuous flow of sulphuric acid is maintained downward over the tower packing material by steadily introducing the acid into the top of the tower through the thistle tube. The acid is lifted from the wide-mouth bottle which serves as the reservoir and into which the acid constantly drains from the tower. The lifting of the acid is accomplished by compressed air. The operation is identical with the air lift some times employed for pumping liquids. Obviously the specific gravity of the liquid being handled, the size of the line bringing in the air, the amount of liquid seal at the top of the tower, the total lift desired, the pressure of the gas being washed and the pressure on the air line are all factors to be considered in assembling and operating such a gas-washing system.

Obviously liquids other than sulphuric acid may be conveniently handled.

Packed Columns For Close Fractionation

L. B. BRAGG
Foster Wheeler Corporation

THE single-cell, conical-type Stedman packing is at present made in three sizes—0.375-inch, 0.750-inch and 25-millimeter (0.984-inch) nominal diameters. The multiple-cell, triangular pyramid-type Stedman packing also is made in three round sizes—2.080-inch, 3.080-inch and 6.080-inch diameters. A fourth packing of this type is made having an equilateral triangular cross-section 6 inches on a side, these sections being fitted together to pack columns of hexagonal cross-section. These packings usually are constructed of 40 x 60-mesh wire cloth, using 0.009-inch diameter wire.

The packings were tested with mixtures of benzene and ethylene dichloride at total reflux and atmospheric pressure. The data obtained were worked up in the form of column operation factors which permit accurate comparisons between various types of packing and different diameters of columns. Data on other types of columns are included. These data have been converted to be comparable with data on ethylene dichloride mixtures and worked up in the same manner.

This paper was delivered before the annual meeting of the American Institute of Chemical Engineers, New Orleans, December 2, 3, and 4, 1940.

IN a paper presented at the Toronto meeting of the American Institute of Chemical Engineers in 1936, D. F. Stedman[14] discussed a new type of tower-packing material. The principles of the operation of this packing were explained and preliminary test data were submitted which indicated the promising characteristics of several sizes and patterns of the packing.

Development of this packing material was carried further by Stedman in the laboratories of the National Research Council of Canada at Ottawa[15] and the packing was patented in the United States,[16] Canada[17] and elsewhere. It is being further developed by Foster Wheeler Corporation and a number of different sizes and types have been produced and studied, test data on the operating characteristics of six different sizes having been published.[3,4,5]

Description of Packing

In the smaller sizes, which at present include 0.375-inch, 0.750-inch and 25-millimeter (0.984-inch) nominal diameters, called Nos. 105, 104 and 112, respectively, the packing is constructed in the single-cell conical type. This type is made of wire cloth which has been embossed and trimmed into flat, truncated, conical discs. A semi-circular hole is cut out of one side of the cone and extends about two thirds of the distance from the edge of the cone to the flat in the center. The discs are welded together alternately back to back and edge to edge, forming a regular series of cells. The holes, which serve as vapor passageways, are located alternately on opposite sides of the section of packing. The construction may be more readily understood by reference to Figure 1.

In operation, reflux liquid flows along the wire cloth and seals the openings of the mesh. The liquid flows out toward the walls of the column on a cone that is concave downward, and then back toward the center of the column on a cone that is concave upward, which is welded to the first cone at the outer edge. The lower cone is welded to another still lower cone at the center and the liquid flows through the mesh at the point of junction, then outward toward the walls on this lower cone, and so on until the liquid drops off the lowest cone of the column. The vapor enters the space between two cones, which are welded around the outer edges, through the vapor hole in the lowest cone. The vapor then flows through the space between these two cones, practically at right angles to the axis of the column, and out through the vapor opening in the upper cone of the pair. The vapor then divides and flows around the point where two cones are joined back to back, and across to the side of the column where it first entered the packing. This flow is repeated until the vapor leaves the packing at the top of the column.

With the single-cell conical type of packing the number of sheets of wire cloth per unit of height of packing decreases with increasing diameter. As a result the contacting efficiency per unit of height of packing decreases rapidly with increasing diameter. This could be offset to some extent by flattening the cones as the diameter increased, but such a change would result in reducing the capacity of the packing and could be made to a limited extent only without destroying the liquid distribution. It is expected that a 37-millimeter (1.457-inch) nominal diameter conical-type packing will be produced, but as will be seen from the data presented hereafter, commencing with about 2-inch diameter, a multiple-cell triangular-pyramid type of packing is preferable.

The triangular-pyramid type also is made of wire cloth which has been punched, blanked and embossed to form circular sheets having a regular pattern of raised triangular pyramids and an upturned lip around the circumference. The pyramids are located on ⅜-inch equilateral triangular centers. The sheets are also perforated with 3/16-inch diameter holes located on ⅜-inch equilateral triangular centers between the pyramids.

The pattern on the circular sheets is placed so

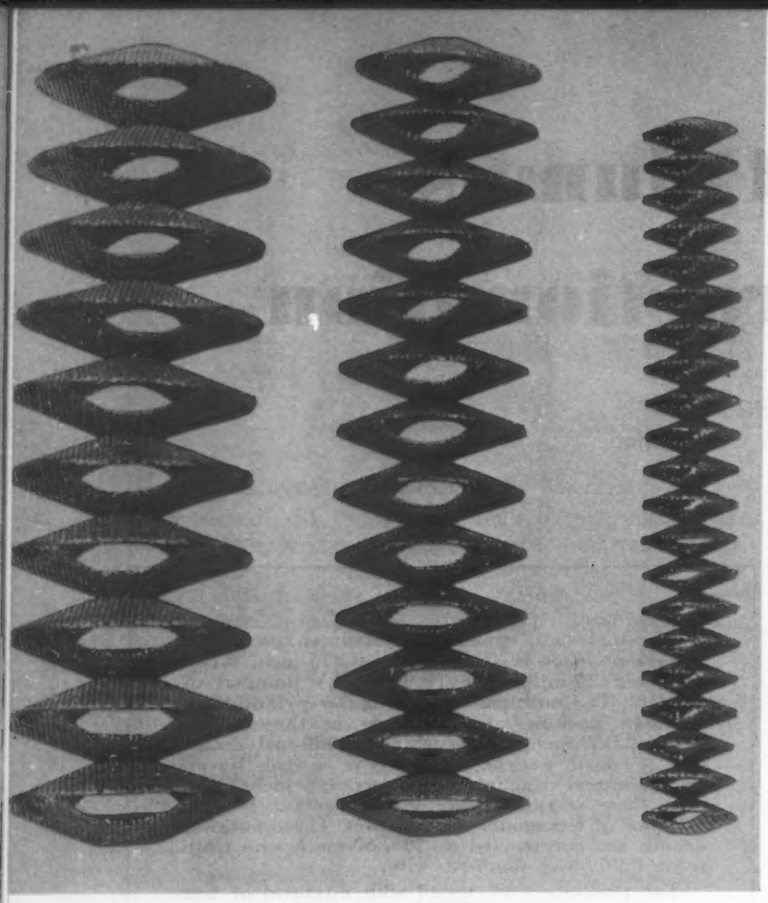


FIGURE 1
Three sizes of Stedman packing—conical type

that by rotating adjacent sheets 120 degrees with respect to each other, the so-called "valleys" at the junctions of the bases of the pyramids of the upper sheet come immediately above the apexes of the pyramids of the lower sheet. The sheets are welded together at these points of contact. This placing of adjacent sheets causes the holes of the lower sheet, which serve as vapor passageways, to be located below the apexes of the pyramids of the upper sheet. The construction may be more readily understood by reference to Figure 2. The three sizes of packing on which tests are reported herein had diameters of 2.080-inch, 3.080-inch and 6.080-inch, called Nos. 128, 107 and 115, respectively.

In operation the liquid flows along the wire cloth and seals the openings of the mesh. The liquid flows down the sides of the triangular pyramids, dividing into three portions as it does so. Then it flows along the mesh at the base of the pyramids until it reaches the center of the so-called "valley" at the junction of the edges of three pyramids. Here it flows through the cloth to the peak of the pyramid of the next lower sheet of cloth which is welded to the upper sheet at this point. The liquid flows continuously in this manner from the top to the bottom of a section of packing, repeatedly dividing into three streams and then combining three streams so as to give a very effective distribution and mixing of the liquid. The tendency of this action to flow liquid toward the walls of the column is counter-balanced by the tendency of the upturned lip to flow liquid from the walls toward the center. The vapor flows upward through the vapor openings into the space below a pyramid. Here the vapor stream divides into three parts and then each part flows upward through vapor openings in the next higher sheet of cloth together with vapor that in each case came from two other vapor openings. This flow is repeated until the vapor leaves the packing at the top of the column, giving good distribution and mixing of the vapors the same as is the case with the liquid.

As the diameter of the column increases it becomes desirable to modify the packing so that standard sections of packing may be used for various column diameters. This desideratum has been satisfied by manufacturing packing having an equilateral triangular cross-section, 6 inches long on a side of the triangle. These sections may then be fitted together to pack a column of hexagonal cross-section of any capacity.

There is a continual mixing and separation of both liquid and vapor so that channeling is not possible. The column in which the packing is inserted must fit the packing closely, so that any openings between the packing and the column are sealed by the liquid to prevent by-passing of the vapor. The underside of the liquid stream is exposed to the vapor as it flows along the mesh of the screen and the irregularities of the woven screen cause turbulence in the liquid stream, so that the liquid is well exposed to the vapors and the the equivalent of an equilibrium contact is quickly attained.

The packing is customarily fabricated from stainless-steel wire cloth 40 x 60 meshes per inch, using wire 0.009-inch in diameter. It may, however, be made of any other material that can be drawn into wires and woven into cloth of the proper mesh, in accordance with the particular use to which the packing is to be put. Other mesh sizes will be satisfactory, so long as the packing has sufficient mechanical strength and the surface tension of the liquid is great enough to seal the openings of the mesh, but certain sizes of mesh and wire diameter are best.[15]

Testing of Packing

The several different types of packings were tested—the conical-type in Pyrex glass columns equipped with silvered vacuum jackets,[3,4] the round triangular pyramid-type in steel columns equipped with vapor jackets,[5] and the hexagonal column in a steel column having a cylindrical outer shell and a hexagonal inner shell. The space between the inner and the outer shells was closed at the top but open to the vapors at the bottom, thereby providing a vapor jacket. The packed columns were connected to a still with a reflux rate measuring device, a column head and a condenser with provision being made for measuring the holdup and friction loss of the column and for obtaining samples of the reflux entering the top of the column and of the reflux leaving the base of the column.[3,4,5] A binary mixture of benzene and ethylene dichloride was used in all tests. All tests were made at atmospheric pressure and with total reflux.

The flood points were determined by increasing the distillation rates by substantially equal steps and noting the point at which the bottom reflux rate decreased suddenly. The points of complete flooding were obtained by increasing the distillation rate until a completely flooded condition was observed in the case of the conical type; or until the friction loss through the columns, fluctuations in the friction loss readings, and a constantly decreasing level of the liquid in the still indicated that the column was completely flooded in the case of the triangular pyramid-type packing. With the triangular pyramid type of packing in the steel columns, since the level

of liquid in the column could not be observed, it was possible to have a condition where the reflux head of the column was partially flooded, which condition apparently existed at the point of so-called complete flooding with the No. 128 packing and possibly with others.

With all types of packing it was found necessary to wet the packing thoroughly before the full efficiency could be developed. The packing was wet by running the column at a rate above its capacity until it became completely flooded. The rate of distillation was next reduced until the flood subsided, and was then set at the point desired for the test being run.

In order to reach an equilibrium condition it was found necessary to continue the distillation for fairly long periods of time. A procedure was adopted whereby at the lower rates of distillation the columns were operated for eight hours before taking the reflux samples. At the higher rates of distillation the columns were operated for five hours before taking the samples, following which it was possible to change the reflux rate to an operating condition which was expected to give a lower efficiency, and then take a second set of samples three hours later. Occasional checks showed that this method of procedure made it unnecessary to regularly obtain check samples.

The reflux samples removed from aobve and below the packing were analyzed by refractive index, and the number of theoretical plates was calculated by means of the equation of Beatty and Calingaert,[2] using values of relative volatility reported by Smith and Matheson.[13] The values of relative volatility are nearly constant over the atmospheric pressure boiling range of mixtures of benzene and ethylene dichloride, but the slight error attendant upon the use of an average value of relative volatility was avoided by using a plot of theoretical plates vs. refractive index.[3,4]

Column Operation Factords

It has been rather common in the past to submit as data on the operation of packed columns, theoretical plates per foot of packed column and the inverse factor H.E.T.P. (height equivalent to a theoretical plate), the holdup of the column in question expressed in some convenient unit of volume measurement, and the friction loss through the column. These several types of data were obtained frequently at various boilup rates, and have been presented by some authors in graphical form comparing the above-mentioned characteristics at various boilup rates.

However, except for the H.E.T.P. factor, the data obtained have generally not been presented on a basis that would permit ready comparison of various types and sizes of packing material. It has been the author's particular purpose in this paper to work out a series of factors presenting the data in such form that it will be readily comparable, one diameter with another and one type of packing with another. The factors used are as follows:

1. As a factor to express the fractionating ability

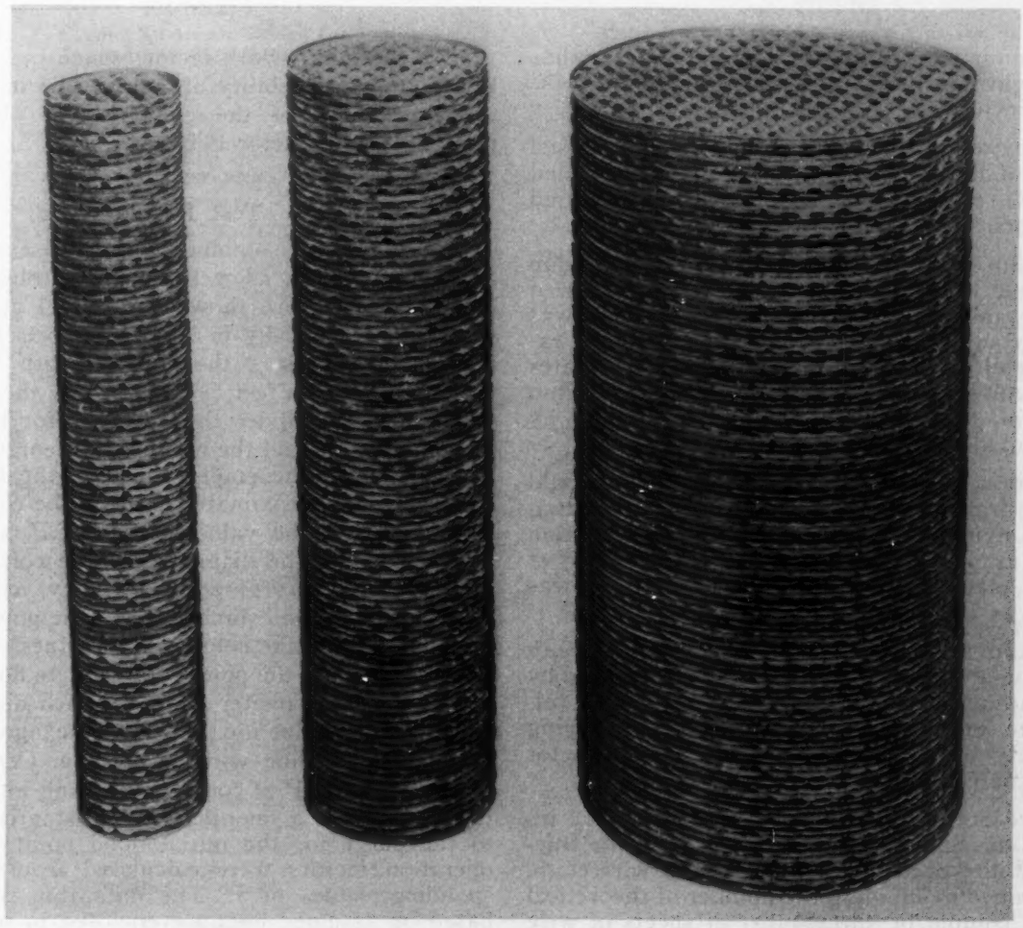


FIGURE 2
Three sizes of Stedman packing—triangular pyramid type

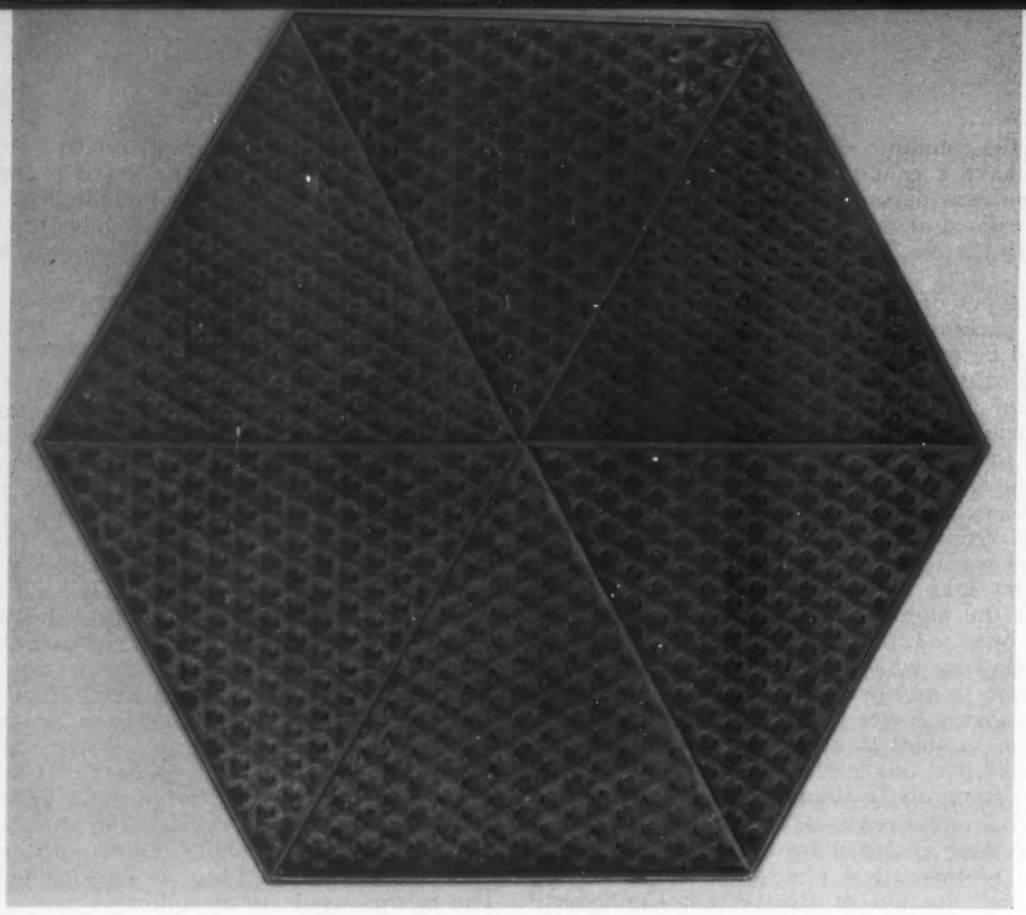


FIGURE 3
Twelve-inch hexagonal column, triangular pyramid type

of the column, the author has used the familiar factor "height equivalent to a theoretical plate" expressed in inches.

2. As a capacity factor, the boilup rate expressed as gallons of liquid boiled up per hour was divided by the cross-sectional area of the column expressed in square inches. This factor was designated as S.

3. A holdup factor, which would express the holdup of the column in terms of the fractionating ability of the column and the throughput of the column, was obtained by dividing the holdup of the column expressed in gallons by the number of theoretical plates in the column and by the boilup rate of the column expressed in gallons per hour and multiplying by 1000, to provide the factor W.

4. A friction loss factor was obtained which would express the friction loss in terms of the fractionating ability by dividing the friction loss of the column expressed as inches of water by the number of theoretical plates in the column. This factor was designated as D.

5. A column work factor, which would express both fractionating ability and throughput, was obtained by dividing the number of theoretical plates in the column by the length of the column, and multiplying this quantity by the capacity factor S, this factor being designated as C.

6. A wire-cloth factor, which is of particular interest with the Stedman packing, indicating the fractionating ability of an individual sheet of wire cloth, was determined by dividing the number of theoretical plates in a column by the number of sheets of wire cloth in the same column. This factor was designated as B.

7. A wire-cloth work factor, which indicated both the fractionating ability of a sheet of wire cloth and the throughput of the column, was obtained by multiplying the factor B by the factor S, to produce a factor E.

Test Results

The test results obtained with the seven sizes of Stedman packing, as well as results obtained with empty columns, are shown in Table 1 and are also presented graphically in Figures 4 to 8. In Table 1 and also in Table 2 the actual length of packing used, expressed in feet, is indicated by the number in the subheading under the headings for the friction loss, the holdup and the number of theoretical plates. In the case of the empty columns, the figure used indicates the approximate length of the column.

In Figure 4 the values of H.E.T.P. and W are plotted against the diameters of the columns using data at the points of peak efficiency, at the initial flood points of the columns and at the points of complete flooding of the columns. No values of H.E.T.P. were obtained at the points of complete flooding with the 3.080-inch diameter and 6.080-inch diameter columns and the value for the 12-inch hexagonal column seemed out of line with other data. Consequently, values of H.E.T.P. at complete flooding were assumed that would give a smooth curve substantially parallel to the curve for the initial flood point. The other operation factors were calculated from the corresponding values of P. The data thus assumed or based on assumed data are enclosed in parentheses.

In Figure 5, values of S and C are shown plotted against the diameter of the columns. In Figure 6,

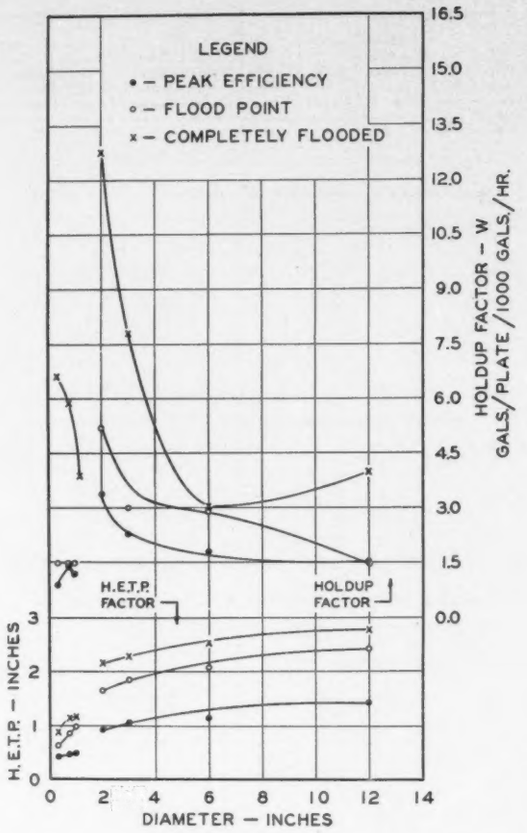


FIGURE 4
H. E. T. P. and W. factor values for various column diameters

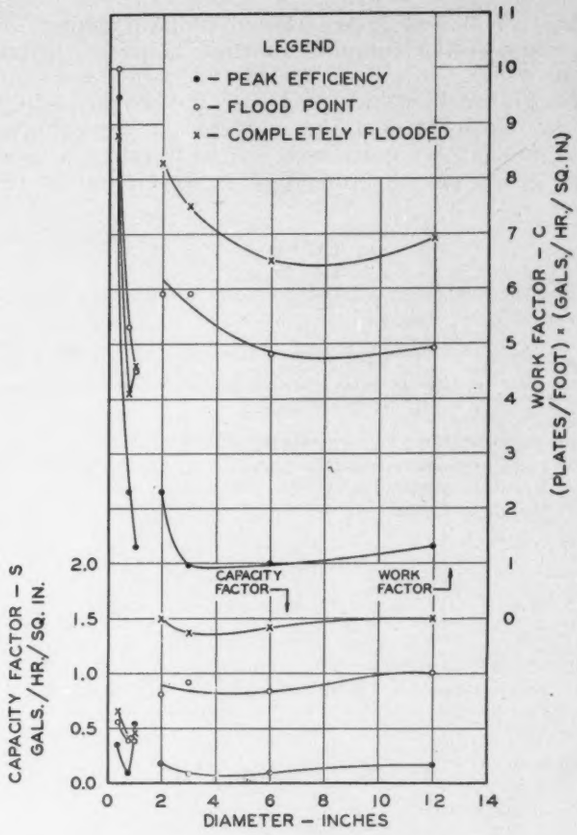


FIGURE 5
Capacity and work factor values for various column diameters

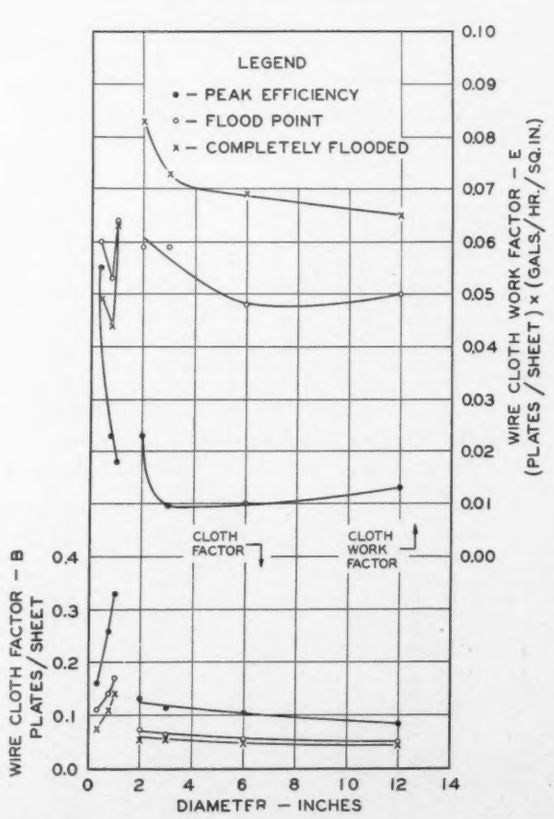


FIGURE 6
Wire cloth and wire cloth work factors for various column diameters

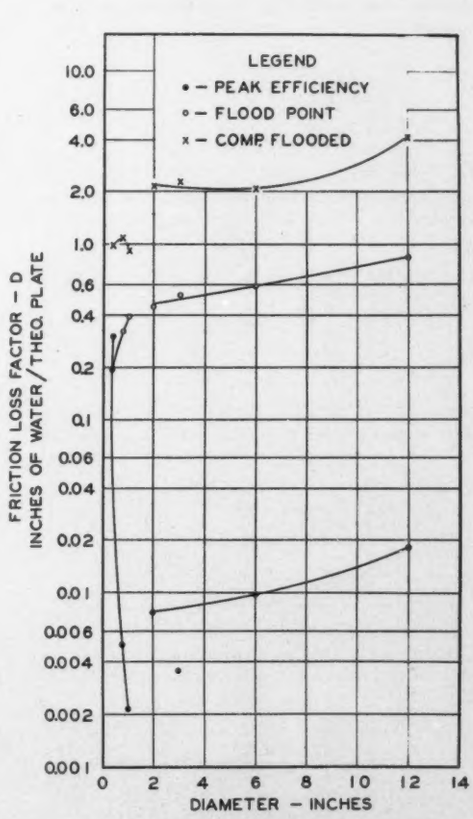


FIGURE 7
Friction loss factor for various column diameters

values of B and E are shown plotted against the diameter of the columns showing a quite constant relationship.

In Figure 7, values of D are plotted on a logarithmic scale against the diameter of the columns. This plot shows quite well the wide range of pressure drops per theoretical plate depending on the

TABLE 1
Test Data

Reflux Rate	Friction Loss	Hold-up	Theoretical Plates in Col. Per Ft.	H. E. T. P. Inches	Capacity Factor	Hold-up Factor	Friction Loss Factor	Work Factor	Wire Cloth Factor	Wire Cloth Work Factor
R	F	H	P		S	W	D	C	B	E
Empty Column, 0.1875-Inch Diameter, A = 0.0276 Sq. In.										
	2F		2P							
0.024	0.03	.....	7.0	3.4	0.9	.....	0.004	3.2	.....	.....
0.029	0.05	.....	6.6	3.6	1.1	.....	0.008	3.6	.....	.....
0.037	0.07	.....	6.4	3.7	1.3	.....	0.011	4.2	.....	.....
0.061	0.15	.....	5.9	4.1	2.2	.....	0.025	6.5	.....	.....
0.066	0.10	.....	5.7	4.2	2.4	.....	0.018	6.8	.....	.....
0.092	0.20	.....	5.4	4.4	3.3	.....	0.037	8.9	.....	.....
0.170	0.30	.....	5.1	4.7	6.2	.....	0.059	15.8	.....	.....
Empty Column, 0.3125-Inch Diameter, A = 0.0768 Sq. In.										
	2F		2P							
0.026	0.05	.....	8.8	2.7	0.34	.....	0.006	1.5	.....	.....
0.033	0.05	.....	6.3	3.8	0.43	.....	0.008	1.3	.....	.....
0.040	0.08	.....	5.3	4.5	0.52	.....	0.015	1.4	.....	.....
0.059	0.13	.....	4.4	5.5	0.77	.....	0.030	1.7	.....	.....
0.073	0.13	.....	3.8	6.3	0.95	.....	0.034	1.8	.....	.....
0.092	0.15	.....	3.3	7.3	1.2	.....	0.045	2.0	.....	.....
0.151	0.20	.....	3.2	7.5	2.0	.....	0.063	3.2	.....	.....
0.182	....	.....	2.4	10.0	2.4	.....	.....	2.9	.....	.....
0.261	....	.....	3.5	6.9	3.4	.....	.....	5.9	.....	.....
Empty Column, 0.375-Inch Diameter, A = 0.111 Sq. In.										
			2P							
0.026	....	.....	9.2	2.6	0.23	.....	.....	1.1	.....	.....
0.033	....	.....	8.8	2.7	0.30	.....	.....	1.3	.....	.....
0.040	....	.....	6.2	3.9	0.36	.....	.....	1.1	.....	.....
0.046	....	.....	5.3	4.5	0.41	.....	.....	1.1	.....	.....
0.053	....	.....	4.2	5.7	0.48	.....	.....	1.0	.....	.....
Empty Column, 0.750-Inch Diameter, A = 0.442 Sq. In.										
			2P							
0.040	....	.....	9.0	2.7	0.09	.....	.....	0.40	.....	.....
0.053	....	.....	6.4	3.8	0.11	.....	.....	0.35	.....	.....
0.066	....	.....	4.3	5.6	0.15	.....	.....	0.32	.....	.....
0.066	....	.....	4.4	5.5	0.15	.....	.....	0.33	.....	.....
0.119	....	.....	1.2	20.	0.27	.....	.....	0.16	.....	.....
0.132	....	.....	1.3	18.5	0.30	.....	.....	0.20	.....	.....
0.185	....	.....	1.2	20.	0.42	.....	.....	0.25	.....	.....
0.238	....	.....	1.0	24.	0.54	.....	.....	0.27	.....	.....
Empty Column, 0.984-Inch Diameter, A = 0.760 Sq. In.										
			2P							
0.040	....	.....	12.5	1.8	0.053	.....	.....	0.33	.....	.....
0.053	....	.....	10.3	2.3	0.070	.....	.....	0.36	.....	.....
0.092	....	.....	2.7	8.9	0.121	.....	.....	0.16	.....	.....
0.132	....	.....	1.7	14.	0.174	.....	.....	0.15	.....	.....
0.185	....	.....	1.7	14.	0.243	.....	.....	0.21	.....	.....
0.211	....	.....	1.6	15.	0.278	.....	.....	0.22	.....	.....
0.238	....	.....	1.6	15.	0.313	.....	.....	0.25	.....	.....
Empty Column, 2.080-Inch Diameter, A = 3.40 Sq. In.										
	4F		4P							
0.5	....	.....	1.7	28	0.15	.....	.....	0.064	.....	.....
0.7	....	.....	1.5	32	0.21	.....	.....	0.079	.....	.....
1.0	....	.....	1.2	40	0.29	.....	.....	0.087	.....	.....
1.5	....	.....	1.0	48	0.44	.....	.....	0.11	.....	.....
2.0	0.17	.....	0.8	60	0.59	.....	0.21	0.12	.....	.....
3.0	0.20	.....	0.7	69	0.88	.....	0.29	0.15	.....	.....
4.0	0.25	.....	0.6	80	1.2	.....	0.42	0.18	.....	.....
6.0	....	.....	0.5	96	1.8	.....	.....	0.23	.....	.....
7.5	0.40	.....	0.4	120	2.2	.....	1.0	0.22	.....	.....
9.0	0.50	.....	0.4	120	2.6	.....	1.3	0.26	.....	.....

Reflux Rate	Friction Loss	Hold-up	Theoretical Plates in Col. Per Ft.	H. E. T. P. Inches	Capacity Factor	Hold-up Factor	Friction Loss Factor	Work Factor	Wire Cloth Factor	Wire Cloth Work Factor
R	F	H	P		S	W	D	C	B	E
Empty Column, 3.080-Inch Diameter, A = 7.43 Sq. In.										
	4F		4P							
0.5	0.04	.....	1.8	27	0.07	.....	0.022	0.032	.....	.....
2.0	....	.....	1.6	30	0.27	.....	.....	0.11	.....	.....
4.0	0.10	.....	1.1	44	0.54	.....	0.091	0.15	.....	.....
7.0	0.15	.....	0.8	60	0.94	.....	0.19	0.19	.....	.....
10.0	0.20	.....	0.8	60	1.35	.....	0.25	0.27	.....	.....
Empty Column, 6.080-Inch Diameter, A = 29.0 Sq. In.										
	4F		4P							
5	....	.....	1.8	27	0.17	.....	.....	0.076	.....	.....
10	....	.....	1.0	48	0.34	.....	.....	0.085	.....	.....
12.5	0.20	.....	0.9	53	0.43	.....	.22	0.097	.....	.....
20	....	.....	0.9	53	0.69	.....	.....	0.16	.....	.....
24	....	.....	0.6	80	0.83	.....	.....	0.12	.....	.....
Packing 105, 0.375-Inch Diameter, A = 0.111 Sq. In.										
	2F	2H	2P						178 Sh./Ft.	
0.024	0.05	.....	20.0	1.20	0.22	.....	0.0025	2.2	0.056	0.012
0.026	0.05	.....	32.6	0.74	0.23	.....	0.0015	3.7	0.092	0.021
0.029	0.10	0.0015	41.6	0.58	0.26	1.2	0.0024	5.4	0.12	0.031
0.034	0.80	0.0020	53.6	0.45	0.31	1.1	0.015	8.3	0.15	0.047
0.037	1.2	0.0019	56.4	0.42	0.32	0.9	0.021	9.0	0.16	0.051
0.040	2.2	0.0021	56.4	0.42	0.36	0.9	0.039	10.	0.16	0.058
0.045	2.4	0.0021	53.3	0.45	0.41	0.9	0.045	11.	0.15	0.061
0.045	2.75	.....	52.2	0.46	0.41	.....	0.053	11.	0.15	0.061
0.048	3.5	0.0022	49.9	0.48	0.43	0.9	0.070	11.	0.14	0.060
0.050	4.0	0.0023	44.8	0.54	0.45	1.0	0.089	10.	0.13	0.058
0.053	4.2	0.0023	44.2	0.54	0.48	1.0	0.095	11.	0.12	0.058
0.055	4.9	0.0023	41.5	0.58	0.50	1.0	0.13	10.	0.12	0.060
0.056	5.0	0.0022	40.9	0.59	0.50	1.0	0.12	10.	0.12	0.060
0.058	7.0	0.0029	39.9	0.60	0.52	1.3	0.18	10.	0.11	0.057
0.059	6.5	0.0024	39.1	0.61	0.53	1.0	0.17	10.	0.11	0.058
0.061*	7.0	0.0032	37.7	0.64	0.55	1.4	0.19	10.	0.11	0.060
0.063	11.0	0.0048	31.8	0.75	0.57	2.4	0.35	9.0	0.089	0.051
0.066	17.0	0.0081	32.5	0.74	0.59	3.8	0.52	9.6	0.091	0.054
0.069	7.35	.....	41.7	0.58	0.62	.....	0.18	13.	0.12	0.074
0.073†	26.0	0.0126	26.5	0.90	0.66	6.5	0.98	8.8	0.074	0.049
Packing 104, 0.750-Inch Diameter, A = 0.442 Sq. In.										
	2F	2H	2P						98 Sh./Ft.	
0.026	0.08	0.0023	43.2	0.56	0.059	2.0	0.0019	1.3	0.22	0.013
0.033	0.20	0.0028	48.0	0.50	0.075	1.8	0.0042	1.8	0.25	0.019
0.040	0.25	0.0028	50.3	0.48	0.090	1.4	0.0050	2.3	0.26	0.023
0.046	0.40	0.0028	49.5	0.48	0.10	1.2	0.0081	2.5	0.25	0.025
0.053	0.65	0.0045	48.3	0.50	0.12	1.8	0.014	2.9	0.25	0.030
0.079	1.25	0.0048	42.7	0.56	0.18	1.4	0.029	3.8	0.22	0.040
0.106	4.5	0.0055	36.7	0.65	0.24	1.4	0.12	4.4	0.19	0.046
0.132	6.2	0.0056	33.7	0.71	0.30	1.3	0.18	5.0	0.17	0.051
0.158	7.4	0.0065	30.6	0.78	0.36	1.3	0.24	5.5	0.16	0.058
0.168*	9.0	.....	27.8	0.86	0.38	.....	0.32	5.3	0.14	0.053
0.172	18.5	0.0123	24.4	0.98	0.39	2.9	0.76	4.8	0.13	0.051
0.178†	22.5	0.0216	20.6	1.16	0.40	5.9	1.1	4.1	0.11	0.044
Packing 112, 0.984-Inch Diameter, A = 0.760 Sq. In.										
	2F	2H	2P						72 Sh./Ft.	
0.034	0.08	0.0022	38.7	0.64	0.045	1.7	0.0021	0.87	0.27	0.012
0.040	0.10	0.0024	48.4	0.50	0.053	1.2	0.0021	1.3	0.34	0.018
0.042	0.10	.....	48.0	0.50	0.055	.....	0.0021	1.3	0.33	0.018
0.053	0.20	0.0034	43.8	0.55	0.070	1.5	0.0046	1.5	0.30	0.021
0.066	0.35	0.0038	41.0	0.59	0.087	1.4	0.0085	1.8	0.29	0.025
0.074	0.45	0.0045	38.7	0.62	0.097	1.6	0.012	1.9	0.27	0.026
0.079	0.55	.....	38.5	0.62	0.104	.....	0.014	2.0	0.27	0.028
0.106	0.90	0.0059	34.8	0.69	0.139	1.6	0.026	2.4	0.24	0.033
0.127	1.2	.....	33.0	0.73	0.167	.....	0.036	2.8	0.23	0.038
0.132	1.6	0.0063	31.1	0.77	0.174	1.5	0.051	2.7	0.22	0.038
0.158	2.5	.....	31.1	0.77	0.208	.....	0.080	3.7	0.22	0.046
0.185	3.4	0.0071	29.5	0.81	0.243	1.3	0.12	3.6	0.21	0.051
0.211	4.8	.....	28.2	0.85	0.278	.....	0.17	3.9	0.20	0.056
0.238	6.5	0.0087	26.3	0.91	0.313	1.4	0.25	4.1	0.18	0.056
0.264	8.5	0.0090	24.6	0.98	0.348	1.4	0.35	4.3	0.17	0.059
0.280	9.5	.....	24.2	0.99	0.368	.....	0.39	4.5	0.17	0.063
0.286*	9.5	0.0095	24.2	0.99	0.376	1.4	0.39	4.5	0.17	0.064
0.298	11.0	0.0219	25.5	0.94	0.392	2.9	0.43	5.0	0.18	0.070
0.306	9.5	.....	26.3	0.91	0.403	.....	0.36	5.3	0.18	0.073
0.317	10.9	0.0103	26.1	0.92	0.417	1.2	0.42	5.4	0.18	0.075
0.324	12.2	.....	25.7	0.93	0.426	.....	0.48	5.5	0.17	0.073
0.330	16.3	0.0206	27.7	0.87	0.434	2.3	0.59	6.0	0.19	0.082
0.343†	19.0	0.0390	20.5	1.17	0.451	3.9	0.93	4.6	0.14	0.063

loading of the column. If a very low pressure drop is desired, this may be had by operation at low throughput whereas if pressure drop is not a factor, operation at high rates of throughput is possible.

Figure 8 shows values of P plotted on a logarithmic scale against the diameter of the column also on a logarithmic scale. Plotted in this manner the data appears to be well represented by straight lines which appear to indicate the values of P that may be expected in large-diameter columns.

Other Types of Packing

Data available in the literature on several other types of packing have been recalculated to obtain values of the operation factors for comparison with Stedman packing. There have also been included data on small empty glass columns of Rose,[11] the concentric glass tube column of Selker, Burk and Lankelma[12] and on the Bruun[6] glass bubble-cap column.

These data are shown in Table 2. All of the test data given in Table 2 were obtained using mixtures other than benzene and ethylene dichloride except those of Hall and Bachman.[9] Without exception all the other mixtures used will permit larger boilup rates expressed as volume of liquid handled than will benzene and ethylene dichloride and will also give lower friction losses at comparable operating conditions such as at the flood point. Consequently, in order that a proper comparison might be made, all of the operation factors have been calculated for equivalent distillation of mixtures of benzene and ethylene dichloride.

In these calculations estimates had to be made of the composition of the liquid at the point in the column at which the reflux rate was measured. From these estimates and figures with regard to comparable maximum vapor velocities and vapor and liquid densities, correction factors were calculated which were used to determine operation factors that would be consistent with those obtained with mixtures of benzene and ethylene dichloride, as indicated in Table 1.

The assumption was made that the holdup varied proportionately to the liquid throughput as a result of which there was no correction of the factor W for various liquids. Actually, the holdup generally decreases less rapidly than the liquid throughput, and

TABLE 1—Continued

Reflux Rate	Friction Loss	Holdup	Theoretical Plates in Col. Per Ft.	H. E. T. P. Inches	Capacity Factor	Holdup Factor	Friction Loss Factor	Work Factor	Wire Cloth Factor	Wire Cloth Work Factor
R	F	H	P		S	W	D	C	B	E

Packing 128, 2.080-Inch Diameter, A = 3.40 Sq. In.

	3F	3H	3P						100 Sh./Ft.	
0.4	0.20	0.08	13.9	2.59	0.12	14.	0.014	0.56	0.046	0.0055
0.5	0.25	0.05	38.3	0.94	0.15	2.6	0.0065	1.9	0.128	0.019
0.6	0.30	0.08	39.0	0.92	0.18	3.4	0.0077	2.3	0.130	0.023
0.75	0.50	0.05	36.7	0.98	0.22	1.8	0.014	2.7	0.122	0.027
1.1	1.25	0.11	30.9	1.17	0.32	3.2	0.040	3.3	0.103	0.033
1.5	2.5	0.16	26.9	1.34	0.44	3.9	0.093	3.9	0.090	0.040
1.5	2.5	0.11	27.5	1.31	0.44	2.6	0.091	4.0	0.092	0.041
2.0	5.0	0.24	25.1	1.44	0.59	4.7	0.20	4.9	0.084	0.050
2.0	5.0	0.18	25.2	1.43	0.59	3.7	0.20	5.0	0.084	0.050
2.5	8.0	0.28	22.2	1.62	0.74	5.2	0.36	5.5	0.074	0.055
2.5	8.0	0.26	22.3	1.61	0.74	4.7	0.36	5.5	0.074	0.055
2.75*	9.5	0.21	.....	.....	0.81	.....	.....	.....	.....	.....
3.0	11.5	0.37	21.0	1.71	0.88	5.8	0.55	6.2	0.070	0.062
3.25	13.0	0.40	21.1	1.70	0.96	5.8	0.62	6.7	0.070	0.067
3.5	14.0	0.32	22.2	1.62	1.1	4.1	0.63	8.1	0.074	0.081
4.0	20.0	0.40	22.4	1.61	1.2	4.4	0.89	9.0	0.075	0.090
4.5	26.0	0.45	23.5	1.53	1.3	4.3	1.1	10.	0.078	0.10
4.75	31.0	0.53	19.5	1.85	1.4	5.7	1.6	9.1	0.065	0.091
5.0†	35.0	1.06	16.6	2.17	1.5	12.8	2.1	8.3	0.055	0.083

Packing 107, 3.080-Inch Diameter, A = 7.43 Sq. In.

	3F	3H	3P						99 Sh./Ft.	
0.5	0.10	0.05	25.2	1.43	0.067	4.0	0.0040	0.56	0.085	0.0057
0.65	0.12	0.05	33.2	1.08	0.087	2.3	0.0036	0.97	0.112	0.0097
0.75	0.17	0.08	32.5	1.11	0.10	3.3	0.0052	1.1	0.109	0.011
1.0	0.25	0.11	30.1	1.19	0.13	3.6	0.0083	1.3	0.101	0.013
1.5	0.55	0.26	27.3	1.32	0.20	6.4	0.020	1.8	0.092	0.018
2.0	0.5	0.19	24.8	1.45	0.27	3.8	0.020	2.2	0.083	0.022
2.5	1.5	0.40	24.0	1.50	0.34	6.6	0.063	2.7	0.081	0.028
3.0	1.5	0.26	23.3	1.55	0.40	3.8	0.064	3.1	0.078	0.031
3.0	1.5	0.26	23.2	1.55	0.40	3.7	0.065	3.1	0.078	0.031
4.0	3.0	0.21	22.2	1.62	0.54	2.4	0.13	4.0	0.075	0.041
4.5	4.0	0.26	21.8	1.65	0.61	2.7	0.18	4.4	0.073	0.045
5.0	5.5	0.29	21.2	1.70	0.67	2.7	0.26	4.7	0.071	0.048
6.0	8.7	0.34	20.2	1.78	0.81	2.8	0.43	5.5	0.068	0.055
6.8*	10.0	0.40	19.4	1.86	0.91	3.0	0.52	5.9	0.065	0.059
7.5	13.5	0.26	20.4	1.76	1.01	1.7	0.66	6.9	0.069	0.070
8.0	20.0	0.34	22.0	1.64	1.08	1.9	0.91	7.9	0.074	0.080
8.5	28.0	0.54	21.5	1.68	1.14	3.0	1.3	8.2	0.072	0.082
9.0	28.6	0.40	20.8	1.73	1.21	2.1	1.4	8.4	0.070	0.085
9.5	30.0	0.78	19.5	1.85	1.28	4.2	1.5	8.3	0.066	0.085
10.0	34.0	1.21	16.6	2.16	1.35	7.3	2.0	7.5	0.056	0.076
10.2†	35.0	1.27	(15.6)	(2.30)	1.37	(8.0)	(2.2)	(7.1)	(0.053)	(0.073)

Reflux Rate	Friction Loss	Holdup	Theoretical Plates in Col. Per Ft.	H. E. T. P. Inches	Capacity Factor	Holdup Factor	Friction Loss Factor	Work Factor	Wire Cloth Factor	Wire Cloth Work Factor
R	F	H	P		S	W	D	C	B	E

Packing 115, 6.080-Inch Diameter, A = 29.0 Sq. In.

	3F	3H	3P						100 Sh./Ft.	
2.0	0.25	0.45	30.1	1.20	0.069	7.5	0.0083	0.69	0.100	0.0069
2.8	0.30	0.16	30.8	1.17	0.097	1.8	0.0097	1.0	0.103	0.010
3.5	0.50	0.18	30.5	1.18	0.12	1.7	0.016	1.2	0.102	0.012
5.0	0.50	0.40	26.5	1.36	0.17	3.0	0.019	1.5	0.088	0.015
5.2	0.50	0.16	26.1	1.38	0.18	1.2	0.019	1.6	0.087	0.016
8.2	1.3	0.32	23.7	1.52	0.29	1.6	0.055	2.3	0.079	0.023
10.0	1.6	0.45	22.5	1.60	0.34	2.0	0.071	2.5	0.075	0.026
10.0	1.6	.....	23.2	1.55	0.34	.....	0.069	2.6	0.077	0.026
12.5	3.0	0.61	22.3	1.61	0.43	2.2	0.13	3.2	0.074	0.032
13.5	3.25	0.53	21.8	1.65	0.47	1.8	0.15	3.4	0.073	0.034
15.0	3.5	0.66	20.6	1.75	0.52	2.1	0.17	3.6	0.069	0.036
17.0	5.5	0.74	20.2	1.78	0.60	2.1	0.27	4.1	0.067	0.040
20.0	6.3	0.66	18.8	1.91	0.69	1.8	0.33	4.3	0.063	0.044
20.0	6.7	0.79	17.9	2.01	0.69	2.2	0.37	4.1	0.060	0.041
22.5	7.0	1.19	17.7	2.03	0.78	3.0	0.39	4.6	0.059	0.046
23.5	9.5	.....	17.3	2.08	0.81	.....	0.55	4.7	0.058	0.047
24.0*	10.0	.....	.....	.....	0.83	.....	.....	.....	.....	.....
25.0	10.6	1.24	17.1	2.11	0.86	2.9	0.62	4.9	0.057	0.049
27.5	15.0	1.72	18.0	2.00	0.95	3.5	0.83	5.7	0.060	0.057
30.0	17.0	1.40	19.0	1.89	1.03	2.4	0.90	6.5	0.063	0.065
32.5	20.0	1.35	20.3	1.77	1.12	2.0	0.98	7.6	0.068	0.076
35.0	23.0	1.21	22.3	1.61	1.21	1.6	1.03	9.0	0.074	0.090
37.0	25.0	1.59	23.0	1.56	1.28	1.9	1.09	9.8	0.077	0.099
39.0	27.0	1.48	23.5	1.53	1.35	1.6	1.15	11.	0.078	0.105
41.0	30.0	2.06	22.2	1.62	1.41	2.3	1.35	10.	0.074	0.104
42.0†	30.0	1.80	(14.2)	(2.53)	(1.45)	(3.0)	(2.11)	(6.9)	(0.047)	(0.069)

Packing 116, 12-Inch Hexagon, A = 93.6 Sq. In.

	2F	2H	2P						99 Sh./Ft.	
12.0	0.25	0.55	16.1	1.49	0.13	2.8	0.016	1.0	0.081	0.011
15.0	0.30	0.40	16.7	1.44	0.16	1.6	0.018	1.3	0.084	0.013
20.0	0.50	0.55	15.2	1.58	0.21	1.8	0.033	1.6	0.077	0.016
30.0	1.00	0.63	13.2	1.82	0.32	1.6	0.076	2.1	0.067	0.021
30.0	1.00	1.06	13.2	1.82	0.32	2.7	0.076	2.1	0.067	0.021
30.0	1.00	0.48	13.0	1.85	0.32	1.2	0.077	2.1	0.066	0.021
40.0	1.75	0.53	12.1	1.98	0.43	1.1	0.145	2.6	0.061	0.026
50.0	2.50	0.63	11.7	2.05	0.53	1.1	0.21	3.1	0.059	0.031
60.0	3.90	0.69	11.3	2.12	0.64	1.0	0.35	3.6	0.057	0.036
70.0	5.00	0.79	10.8	2.22	0.75	1.0	0.46	4.0	0.055	0.041
80.0	6.30	0.92	10.1	2.38	0.85	1.1	0.62	4.3	0.051	0.043
85.0	6.90	0.92	9.8	2.45	0.91	1.1	0.70	4.5	0.049	0.045
90.0	8.00	1.00	9.7	2.46	0.96	1.1	0.83	4.6	0.049	0.047
90.0	7.90	0.92	9.5	2.52	0.96	1.1	0.83	4.5	0.048	0.046
93.0*	8.6	.....	.....	.....	0.99	.....	.....	.....	.....	.....
95.0	9.00	1.11	10.2	2.35	1.0	1.1	0.88	5.1	0.052	0.052
100.0	10.0	1.22	11.2	2.14	1.1	1.1	0.89	6.2	0.057	0.063
110.0	12.7	1.48	11.6	2.07	1.2	1.1	1.1	7.0	0.059	0.071
120.0	17.0	1.85	11.7	2.05	1.3	1.3	1.5	7.6	0.059	0.077
130.0	24.0	3.96	11.3	2.12	1.4	2.7	2.1	7.9	0.057	0.080
138.0	32.0	5.02	11.0	2.18	1.5	3.3	2.9	8.3	0.056	0.084
140.0†	36.0	4.73	10.7	2.24	1.5	3.2	3.4	8.0	0.054	0.081
140.0†	36.0	4.73	(8.6)	(2.78)	1.5	(4.0)	(4.2)	(6.5)	(0.044)	(0.065)

* Initial Flood Point of Column.
† Column Completely Flooded.

TABLE 2
Data from Literature

Reflux Rate	Friction Loss	Holdup	Theoretical Plates in Col. per Ft.	H.E.T.P. Inches	Capacity Factor	Holdup Factor	Friction Loss Factor	Work Factor
R	F	H	P		S	W	D	C
Empty Column,[11] 0.118-Inch Diameter, A = 0.0109 Sq. In.								
0.009	....	.....	9.5	1.3	0.8	....	.....	7.6
0.013	.....	.....	7.0	1.7	1.1	.....	.....	7.7
0.016	.....	.....	6.0	2.0	1.4	.....	.....	8.4
0.021	.....	.....	3.0	4.0	1.8	.....	.....	5.4
0.025	.....	.....	4.0	3.0	2.1	.....	.....	8.4
0.032	.....	.....	2.0	6.0	2.7	.....	.....	5.4
0.048	.....	.....	1.0	12.0	4.1	.....	.....	4.1
Empty Column,[11] 0.236-Inch Diameter, A = 0.0438 Sq. In.								
0.0026	.....	.....	17.5	0.69	0.06	.....	.....	1.1
0.0034	.....	.....	13.0	0.92	0.07	.....	.....	0.9
0.0071	.....	.....	6.0	2.0	0.15	.....	.....	0.9
0.013	.....	.....	4.0	3.0	0.27	.....	.....	1.1
0.014	.....	.....	2.0	6.0	0.29	.....	.....	0.6
0.022	.....	.....	2.0	6.0	0.46	.....	.....	0.9
0.030	.....	.....	2.0	6.0	0.63	.....	.....	1.3
0.040	.....	.....	1.0	12.	0.84	.....	.....	0.8
0.079	.....	.....	1.0	12.	1.7	.....	.....	1.7
0.098	.....	.....	0.5	24.	2.1	.....	.....	1.1
0.127	.....	.....	0.5	24.	2.7	.....	.....	1.4
Concentric Glass Tube Column,[12] A = 0.16 Sq. In. Equivalent Diameter = 0.451 Inches								
	4.7F	4.7H	4.7P					
0.026	0.12	.....	84.9	0.67	0.13	.....	0.0021	2.4
0.051	0.14	.....	97.2	0.59	0.26	.....	0.0021	5.4
0.062	0.17	.....	76.7	0.74	0.31	.....	0.0033	5.1
0.067	0.19	0.0021	69.0	0.82	0.34	0.45	0.0041	5.0
0.022	0.10	0.0098	89.4	0.64	0.11	0.50	0.0017	2.1
0.032	0.12	0.0014	79.6	0.72	0.16	0.55	0.0022	2.7
0.033	0.13	.....	64.9	0.88	0.16	.....	0.0030	2.2
0.048	0.15	.....	72.2	0.79	0.24	.....	0.0031	3.7
0.055	0.19	.....	75.5	0.76	0.27	.....	0.0037	4.3
Bubble-Cap Column,[6] 0.984-Inch Diameter, A = 0.760 Sq. In. 2 Centimeter Sections								
	0.33F	0.33H	0.33P					
0.081	.....	0.00092	5.4	0.73	0.10	2.1	.....	1.6
0.16	.....	0.00092	4.8	0.82	0.19	1.2	.....	2.8
0.34	.....	0.00092	3.7	1.1	0.41	0.73	.....	4.6
0.040	.....	0.00092	4.9	0.80	0.042	4.7	.....	0.62
0.081	.....	0.00092	4.7	0.84	0.084	2.4	.....	1.2
0.16	.....	0.00092	4.3	0.92	0.17	1.3	.....	2.2
0.32	.....	0.00092	3.8	1.0	0.33	0.76	.....	3.8
4 Centimeter Sections								
	0.66F	0.66H	0.66P					
0.071	.....	0.0018	4.4	1.8	0.085	5.8	.....	0.57
0.16	.....	0.0018	4.2	1.9	0.19	2.7	.....	1.2
0.39	.....	0.0018	3.7	2.1	0.47	1.2	.....	2.6
0.057	.....	0.0018	5.1	1.5	0.068	6.2	.....	0.53
0.12	.....	0.0018	4.7	1.7	0.12	3.2	.....	0.86
0.19	.....	0.0018	4.4	1.8	0.20	2.3	.....	1.3
0.33	.....	0.0018	4.2	1.9	0.34	1.3	.....	2.2
0.49	.....	0.0018	4.0	2.0	0.51	0.9	.....	3.1
8 Centimeter Sections								
	1.31F	1.31H	1.31P					
0.076	.....	0.0058	5.7	2.8	0.091	13.	.....	0.40
0.33	.....	0.0058	4.9	3.2	0.39	3.6	.....	1.5
0.12	.....	0.0058	5.0	3.1	0.12	10.	.....	0.46
0.35	.....	0.0058	5.0	3.1	0.36	3.3	.....	1.4
0.46	.....	0.0058	4.6	3.4	0.48	2.7	.....	1.7
One Turn Glass Helices,[19] Diameter 0.394-Inch, A = 0.122 Sq. In.								
	1.33F	1.33H	1.33P					
0.029	.....	.....	12.5	1.4	0.20	.....	.....	1.9
0.034	.....	.....	12.5	1.4	0.23	.....	.....	2.2
0.063	.....	0.0021	11.5	1.55	0.43	2.9	.....	3.7
0.095	.....	.....	12.5	1.4	0.65	.....	.....	6.1
0.108	.....	.....	11.5	1.55	0.74	.....	.....	6.4
0.108	.....	.....	11.5	1.55	0.74	.....	.....	6.4
0.108	.....	.....	11.5	1.55	0.74	.....	.....	6.4
0.111	.....	.....	11.5	1.55	0.76	.....	.....	6.6
0.111	.....	.....	12.0	1.45	0.76	.....	.....	6.8
0.111	.....	.....	11.5	1.55	0.76	.....	.....	6.6

Reflux Rate	Friction Loss	Holdup	Theoretical Plates in Col. per Ft.	H.E.T.P. Inches	Capacity Factor	Holdup Factor	Friction Loss Factor	Work Factor
R	F	H	P		S	W	D	C
4 mm. x 6 mm. — 0.5 mm. Carding Teeth[19] Diameter 1.26-Inch, A = 1.25 Sq. In.								
	9.0F	9.0H	9.0P					
0.48	3.7	.....	38.0	2.9	0.30	.....	0.14	1.3
0.53	3.7	.....	42.5	2.6	0.33	.....	0.13	1.6
0.55	3.5	.....	50.5	2.2	0.34	.....	0.10	1.9
0.58	2.7	.....	40.5	2.8	0.36	.....	0.10	1.6
0.61	4.3	.....	35.0	3.2	0.38	.....	0.18	1.5
1.21	19.8	.....	38.0	2.9	0.75	.....	0.77	3.2
1.27	23.6	.....	33.0	3.4	0.78	.....	1.1	2.9
1.32	19.3	.....	35.5	3.1	0.81	.....	0.81	3.2
One Turn 5/32-Inch—No. 26 Wire Nickel Helices[19] Diameter 1.26-Inch, A = 1.25 Sq. In.								
	9.0F	9.0H	9.0P					
1.37	9.1	.....	21.5	5.3	0.84	.....	0.63	2.0
1.45	9.6	.....	20.5	5.5	0.89	.....	0.70	2.0
1.48	9.6	.....	22.0	5.1	0.91	.....	0.65	2.2
1.53	12.	.....	21.5	5.3	0.94	.....	0.83	2.2
1.56	9.1	.....	18.0	6.3	0.96	.....	0.75	1.9
1.58	12.	.....	29.0	3.9	0.97	.....	0.62	3.1
1.66	17.	.....	29.5	3.8	1.02	.....	0.86	3.3
1.64*	.....	.....	.....	.....	1.01	.....	.....	.....
One Turn 1/8-Inch Diameter—No. 26 Wire Nickel Helices[8] Diameter 1.26-Inch, A = 1.25 Sq. In.								
	43F	43H	43P					
0.64	21	.....	94	5.3	0.39	.....	0.33	0.85
1.08	40	.....	98	5.0	0.66	.....	0.61	1.5
1.08	59	.....	116	4.3	0.66	.....	0.76	1.8
1.11	43	.....	122	4.1	0.67	.....	0.52	1.9
1.24	51	.....	98	5.0	0.75	.....	0.78	1.7
Single Turn 3/32-Inch Diameter—No. 26 Wire Helices[18] Diameter 0.79-Inch, A = 0.49 Sq. In.								
	1.96F	1.96H	1.96P					
0.079	.....	.....	22.0	1.07	0.12	.....	.....	1.3
0.095	.....	.....	22.5	1.04	0.15	.....	.....	1.7
0.21	.....	.....	17.5	1.34	0.33	.....	.....	3.0
0.30	.....	.....	18.5	1.27	0.47	.....	.....	4.4
0.36	.....	.....	16.0	1.47	0.57	.....	.....	4.7
	9.25F	9.25H	9.25P					
0.074	.....	.....	100	1.11	0.12	.....	.....	1.3
0.17	7.5	.....	100	1.11	0.27	.....	0.11	2.9
0.23	.....	.....	113	0.98	0.36	.....	.....	4.4
0.24	9.6	.....	103	1.08	0.38	.....	0.14	4.2
0.29	10.7	.....	101	1.10	0.46	.....	0.16	5.0
0.33	.....	.....	102	1.09	0.52	.....	.....	5.7
Column Diameter 2.0-Inch,[7] A = 3.14 Sq. In. 1/2 x 1/2 Inch Carbon Raschig Rings								
	8.5F	8.5H	8.5P					
3.54	5.9	.....	14.5	7.0	0.87	.....	0.61	1.5
2.3	3.2	.....	13.5	7.5	0.56	.....	0.35	0.90
0.77	0.5	.....	12.5	8.2	0.19	.....	0.06	0.28
1/2 x 1/2 Inch Stoneware Raschig Rings								
2.3	2.1	.....	13.5	7.5	0.56	.....	0.23	0.89
4.5	9.1	.....	17.	6.0	1.1	.....	0.80	2.2
3/8 x 3/8 Inch Stoneware Raschig Rings								
2.0	7.5	.....	18.	5.7	0.49	.....	0.62	1.0
0.85	0.5	.....	14.5	7.0	0.21	.....	0.05	0.36
1.3	1.1	.....	15.5	6.6	0.32	.....	0.11	0.58
1.7	2.1	.....	15.5	6.6	0.42	.....	0.20	0.77
0.37	0.3	.....	16.5	6.2	0.091	.....	0.027	0.18
2.7	4.3	.....	15.5	6.6	0.66	.....	0.41	1.2
1.	7.5	.....	19.	5.4	0.52	.....	0.59	1.2
26	.....	.....	16.	6.4	0.064	.....	.....	0.12
1.1	1.6	.....	15.	6.8	0.27	.....	0.16	0.48

Reflux Rate	Friction Loss	Holdup	Theoretical Plates in Col. per Ft.	H.E.T.P. Inches	Capacity Factor	Holdup Factor	Friction Loss Factor	Work Factor
R	F	H	P		S	W	D	C
¼ x ¼ Inch Carbon Raschig Rings								
1.3	14.	.....	21.5	4.7	0.32	.....	1.0	0.81
1.1	9.	.....	19.	5.4	0.27	.....	0.7	0.60
0.85	5.	.....	20.	5.1	0.21	.....	0.4	0.48
0.45	2.	.....	20.5	5.0	0.11	.....	0.1	0.27
½ Inch Clay Berl Saddles								
3.67	.....	.....	18.	5.7	0.90	.....	.....	1.9
3.20	.....	.....	15.5	6.6	0.79	.....	.....	1.4
2.24	.....	.....	14.5	7.0	0.55	.....	.....	0.94
1.95	.....	.....	14.5	7.0	0.48	.....	.....	0.82
0.90	.....	.....	14.5	7.0	0.22	.....	.....	0.38
0.16	.....	.....	13.5	7.5	0.039	.....	.....	0.062
4.25	.....	.....	18.	5.7	1.0	.....	.....	2.1
3.90	.....	.....	17.5	5.8	0.96	.....	.....	2.0
Six-Mesh Carborundum								
0.58	5.	.....	51.	2.0	0.14	.....	0.14	0.84
0.98	27.	.....	57.	1.8	0.24	.....	0.70	1.6
1.03	42.	.....	60.	1.7	0.25	.....	1.0	1.8
0.24	2.	.....	62.	1.6	0.059	.....	0.05	0.43
¼ Inch I.D. Aluminum Single-Turn Helices								
5.2	.....	.....	17.	6.0	1.3	.....	.....	2.6
5.6	.....	.....	17.5	5.8	1.4	.....	.....	2.9
3/16 Inch I.D. Aluminum Single-Turn Helices								
3.2	4.	.....	19.	5.4	0.79	.....	0.3	1.8
5.3	14.	.....	23.5	4.3	1.3	.....	0.9	3.6
5.1	12.	.....	26.5	3.8	1.3	.....	0.7	4.1
4.5	9.6	.....	27.5	3.7	1.1	.....	0.5	3.6
5/32 Inch I.D. Nickel Single-Turn Helices								
4.7	13.	.....	28.5	3.6	1.2	.....	0.7	4.0
4.2	12.	.....	32.5	3.1	1.0	.....	0.6	3.8
2.6	5.	.....	32.5	3.1	0.64	.....	0.2	2.4
1/8 Inch I.D. Nickel Single-Turn Helices								
2.6	.....	.....	45.	2.3	0.64	.....	.....	3.4
3/32 Inch I.D. Stainless-Steel Single-Turn Helices								
2.0	12.	.....	44.	2.3	0.49	.....	0.41	2.5
1.2	7.	.....	51.	2.0	0.29	.....	0.20	1.7
0.53	2.	.....	68.	1.5	0.13	.....	0.04	1.0
2.9	20.	.....	46.	2.2	0.71	.....	0.65	3.8
1.2	6.4	.....	53.	1.9	0.29	.....	0.18	1.8
1/8 x 7/32 Inch Carding Teeth								
3.9	25.	.....	40.	2.5	0.96	.....	0.93	4.5
3.5	20.	.....	41.5	2.5	0.86	.....	0.72	4.2
2.7	10.	.....	46.5	2.2	0.66	.....	0.32	3.6
2.4	8.	.....	47.5	2.1	0.59	.....	0.25	3.3
1.9	5.	.....	49.5	2.1	0.47	.....	0.15	2.7
1.6	4.	.....	51.	2.0	0.39	.....	0.12	2.3
1.2	3.	.....	52.	2.0	0.29	.....	0.09	1.8
3-6 Mesh Silicon Carbide,[9] 1.24-Inch Diameter, A = 1.21 Sq. In.								
	4.9F	4.9H	4.9P					
1.2*	.....	.....	20.	2.9	1.0	.....	.....	4.1
Spinning-Band Column,[1] 0.26-Inch Diameter, A = 0.053 Sq. In.								
	17.9F	17.9H	17.9P					
0.043	.....	0.0019	70	3.1	0.56	0.63	.....	2.2
0.079*	.....	.....	48	4.5	1.0	.....	.....	2.7

Reflux Rate	Friction Loss	Holdup	Theoretical Plates in Col. per Ft.	H.E.T.P. Inches	Capacity Factor	Holdup Factor	Friction Loss Factor	Work Factor
R	F	H	P		S	W	D	C
Spiral Screen Packing,[10] 0.75-Inch Diameter, 67 Turns/Ft., A = 0.393 Sq. In. Cupped Spiral No. 4, Equivalent Diameter = 0.708 Inches								
0.0053	.....	.....	21.8	0.55	0.010	.....	.....	0.22
0.022	.....	0.0012	17.8	0.67	0.042	2.9	.....	0.75
0.050	Approx. 0.53	0.0014	17.7	0.68	0.095	1.6	0.04	1.7
0.086	.....	0.0017	17.7	0.68	0.16	1.1	.....	2.8
0.137	.....	0.0024	17.0	0.71	0.26	1.0	.....	4.4
0.197	.....	0.0053	13.4	0.90	0.38	1.9	.....	5.1
Spiral Screen Packing,[10] 0.75-Inch Diameter, 72 Turns/Ft., A = 0.393 Sq. In. Collapsed Tube No. 3, Equivalent Diameter = 0.708 Inches								
0.0066	.....	.....	22.6	0.54	0.013	.....	.....	0.29
0.021	.....	.....	25.0	0.49	0.040	.....	.....	1.0
0.029	.....	.....	25.6	0.47	0.055	.....	.....	1.4
0.069	.....	.....	28.5	0.43	0.13	.....	.....	3.7
0.077	.....	.....	30.0	0.40	0.15	.....	.....	4.5
0.082	.....	.....	31.5	0.39	0.16	.....	.....	5.1
0.100	.....	.....	31.5	0.39	0.19	.....	.....	6.0
0.127	.....	.....	21.0	0.58	0.24	.....	.....	5.0
0.132	.....	.....	20.0	0.61	0.25	.....	.....	5.0
Spiral Screen Packing,[10] 0.5-Inch Diameter, 67 Turns/Ft., A = 0.175 Sq. In. Equivalent Diameter = 0.472 Inches								
0.0066	.....	.....	17.7	0.68	0.028	.....	.....	0.50
0.022	.....	0.0007	17.7	0.68	0.094	1.8	.....	1.7
0.057	.....	0.0009	17.7	0.68	0.24	0.9	.....	4.3
0.082	.....	0.0013	17.6	0.69	0.35	0.9	.....	6.2
0.099	.....	0.0019	16.5	0.74	0.42	1.2	.....	6.9

* Initial Flood Point of Column.

this assumption favors data using mixtures of hydrocarbons which allow larger values of R than benzene-ethylene dichloride mixtures.

The data of Rose[11] were obtained with mixtures of benzene and carbon tetrachloride and the values of R were reduced 8 percent in calculating S and C. Selker, Burk and Lankelma[12] used two mixtures. In the results obtained with n-heptane and methylcyclohexane the values of R were reduced 19 percent in calculating S and C, while the values of F were increased 48 percent in calculating D. In the results obtained with iso-octane and methylcyclohexane the values of R were reduced 21 percent while calculating S and C, while the values of F were increased 48 percent in calculating D. Bruun[6] also used two mixtures. Values of R were reduced 9 percent in calculating S and C from the test data in which mixtures of carbon tetrachloride and benzene were used, while they were reduced 21 percent in the calculations involving data in which mixtures of n-heptane and toluene were used.

Tongberg, Quiggle and Fenske[19] used four mixtures n-heptane and toluene, n-heptane and methylcyclohexane, carbon tetrachloride and benzene, and methylcyclohexane and toluene. Only data from the first two mixtures were considered in this paper, the other data giving lower plate efficiencies. With the first mixture R was reduced 16 percent in calculating S and C. With the second mixture R was reduced 23 percent in calculating S and C, while F was increased 49 percent in calculating D.

Fenske, Tongberg, Quiggle and Cryder[8] used mixtures of n-heptane and methylcyclohexane and values of R were reduced 24 percent in calculating S and C, while values of F were increased 49 percent in calculating D. Tongberg, Lawroski and Fenske[18] used the same mixture and values of R were reduced 23

percent in calculating S and C. Fenske, Lawroski and Tongberg[7] used the same mixture, the values of R being reduced 23 percent while calculating S and C, the values of F being increased 49 percent in calculating D. In this case only data obtained after flooding the column were used. Baker, Barkenbus and Roswell[1] also used mixtures of n-heptane and methylcyclohexane and values of R were reduced 28 percent in calculating S and C, while for the same mixture used by Lecky and Ewell[10] values of R were reduced 25 percent in calculating S and C with F being increased 49 percent in calculating D.

It is interesting to note that, while a few of the several types of columns give lower pressure drops per theoretical plate and two combine low pressure drop and low liquid holdup per theoretical plate per unit of throughput, all these columns have higher values of H. E. T. P. than Stedman packed columns of equivalent diameter. One column shows a lower value of H. E. T. P. but has a higher pressure drop per theoretical plate and higher holdup per theoretical plate per unit of throughput. In most cases the flood points of the columns were not determined although it is obvious that some have higher allowable throughputs than the Stedman packed column of corresponding diameter. Considering the above, it is believed that the Stedman packed column offers a better combination of operating characteristics for close fractionation in all except a few special cases. Stedman packing also seems to be the only packing material offering a large number of theoretical plates per foot of height in the larger diameters.

Nomenclature

A = Cross-sectional area of column—Square inches
R = Liquid reflux rate—Gallons per hour
F = Friction loss through column—Inches of water per foot
H = Liquid and vapor holdup of column—Gallons per foot
P = Theoretical plates in column—Plates per foot
H.E.T.P. = Height equivalent to a theoretical plate in inches
S = Capacity factor for column—Gallons per hour per square inch
W = Holdup factor for column—Gallons per theoretical plate per 1000 gallons of throughput per hour
D = Friction loss factor for column—Inches of water per theoretical plate
C = Work factor for column—Plates per foot × gallons per hour per square inch
B = Wire cloth factor for column—Theoretical plates per sheet of wire cloth
E = Wire cloth work factor for column—Theoretical plates per sheet of wire cloth × gallons per hour per square inch.

Acknowledgment

The author wishes to acknowledge the services of L. Nilssen and S. Finelli, who conducted most of the laboratory tests.

Literature Cited

[1] Baker, R. H., Barkenbus, C. and Roswell, C. A., Ind. Eng. Chem. Anal. Ed., 12, 468-71 (1940).
[2] Beatty, H. A., and Calingaert, G., Ind. Eng. Chem., 26, 504-8 (1934).
[3] Bragg, L. B., Ibid., Anal. Ed., 11, 283-7 (1939).
[4] Bragg, L. B., Refiner, 18, 295-8 (1939).
[5] Bragg, L. B., Ind. Eng. Chem., 33, (1941).
[6] Bruun, J. H., Ibid., Anal. Ed., 8, 224-6 (1936).
[7] Fenske, M. R., Lawroski, S. and Tongberg, C. O., Ind. Eng. Chem., 30, 297-300 (1938).
[8] Fenske, M. R., Tongberg, C. O., Quiggle, D. and Cryder, D. S., Ibid., 28, 644-5 (1936).
[9] Hall, H. J., and Bachman, G. B., Ibid., Anal. Ed., 10, 548-9 (1938).
[10] Lecky, H. S., and Ewell, R. H., Ibid., 12, 544-7 (1940).
[11] Rose, Arthur, Ind. Eng. Chem., 28, 1210-12 (1936).
[12] Selker, M. L., Burk., R. E. and Lankelma, H. P., Ibid., Anal. Ed., 12, 352-5 (1940).
[13] Smith, E. R., and Matheson, H., Bur. Standards—J. Research, 20, 641-50 (1938).
[14] Stedman, D. F., Trans. Am. Inst. Chem. Engrs., 33, 153-61 (1937).
[15] Stedman, D. F., Can. J. Research, 15B, 383-400 (1937).
[16] Stedman, D. F., U. S. Patent, 2,047,444 (July 14, 1936).
[17] Stedman, D. F., Canadian Patent, 361,043 (October 6, 1936).
[18] Tongberg, C. O., Lawroski, S., and Fenske, M. R., Ind. Eng. Chem., 29, 957-8 (1937).
[19] Tongberg, C. O., Quiggle, D., and Fenske, M. R., Ibid., 26, 1213-17 (1934).

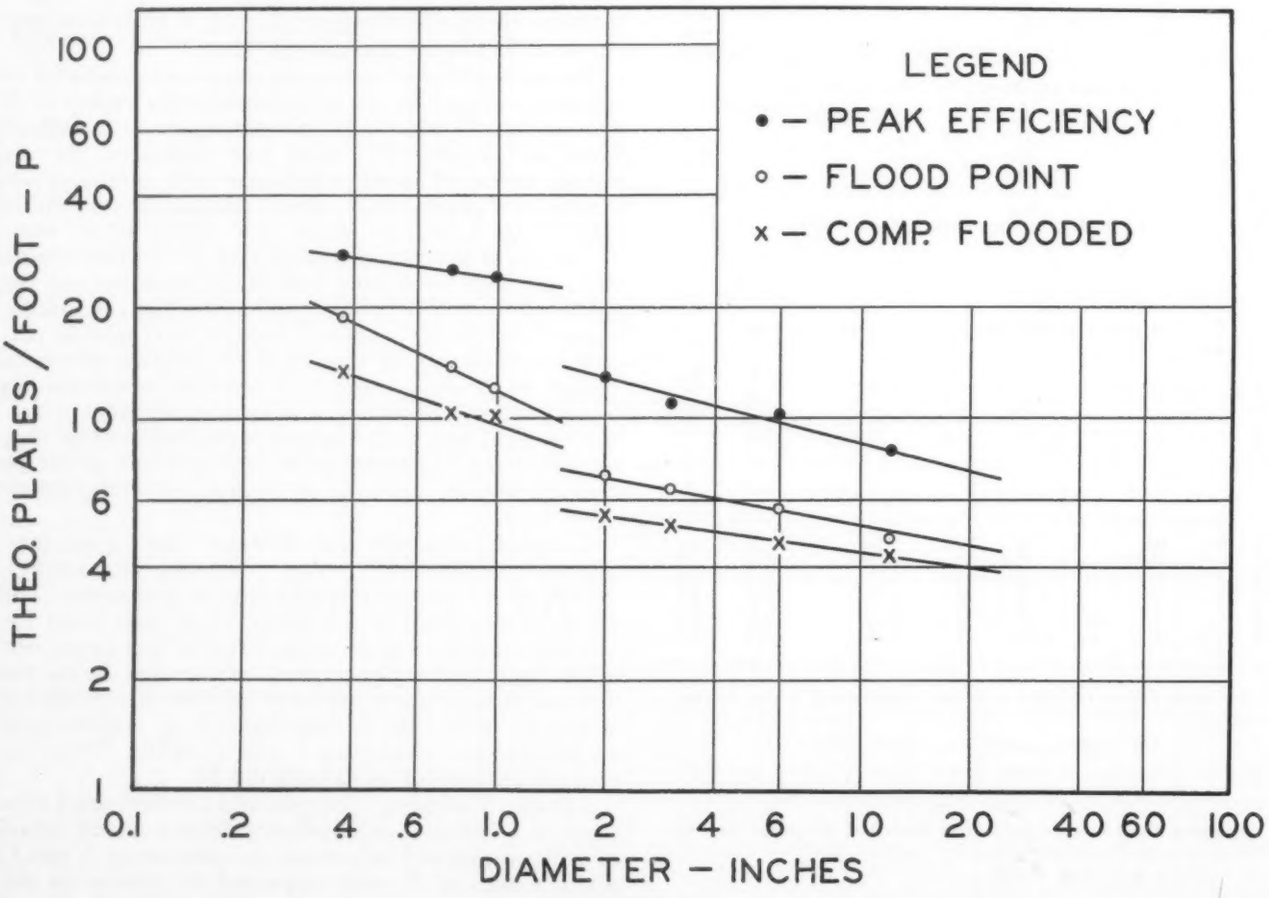


FIGURE 8

Theoretical plates per foot for various column diameters

Laboratory Oxidation Tests For Lubricants

DR. F. JOSTES and DR. A. HANN
Contribution from the Chemical Institute of the Technical High School, Berlin

(Translated from *Oel u. Kohle*, 15, No. 26, 1939, Page 515)

THERE are increasing demands made for engine lubricants which are resistant to rapid ageing and deterioration during use, since the alteration of viscosity of an oil and formation of tarry or cokey deposits determine the value of these oils and affect the life and output of power engines to a very great degree. One desired, therefore, to seek and obtain some laboratory method in order to test oils for their ageing tendencies, and to obtain more accurate data as to what oils do in general. For one reason, for instance, to standardize refining methods in advance in order to produce more resistant oils, and secondly, to be able to recommend a definite oil grade for certain types of engines upon which the public can rely.

To evaluate oils for both these aspects of the lubrication problem calls for a test method which is reliable and not time-consuming. Great effort has been expended in seeking methods which might be feasible, using ordinary laboratory accessories in order to arrive at some procedure in testing ageing tendencies of oils. The difficulty which one meets is, of course, the fact that the conditions in an engine or gasoline motor cannot be exactly duplicated in any laboratory test. This is all the more difficult since it is not definitely known at present just what really occurs when an oil deteriorates, forms sludge or in general when it is said to "oxidize."

Test Methods

Experience has taught that an oil is suitable only for a particular condition or a special motor when it has previously passed some arbitrary test in that type motor or has given good results in some specific engine. Going one step further, if all oils are to be tested in one special type of engine, then such results based on a special engine test cannot be translated into coherent terms when applied to some other type of motor. The varied construction of many "makes" of motors, and the very many varied demands made on engines of today under which they operate greatly influences the tendency one way or another as to whether an oil may or may not rapidly deteriorate in use. The nature of the fuel used in motors has a great bearing on the way a lubricating behaves, as was pointed out by Kadmer[1] and more recently by Kern.[2] It stands to reason then that a result obtained in a certain motor under certain conditions will answer only at most one definite question as to deterioration of oils—some one property of an oil which such specialized test will naturally magnify.

Of still more uncertain character are the relations underlying the laboratory procedures for laboratory oxidation tests; because here attempts are made to cause oils to oxidize or break down in an artificial manner or under artificial conditions, quite different from those found in the motor. In order to cut down the time of testing conditions then are so chosen to hasten the oxidation which are not at all found to exist in operations, and which tend to complicate any laboratory procedure; such laboratory test conditions in general are usually more severe on the oil than those found to exist in actual operating units.

In times past and at present quite an imposing list of tests has been proposed and developed, which claim definitely to predict the ageing tendencies of an oil during actual use. Such an array of tests already indicates that there are many difficulties in judging an oil by any laboratory method. These methods do not only employ vastly different conditions and possess many differences (temperature, oxygen or air, volume of latter, catalysts), under which an oil is going to be judged, but they also differentiate themselves into methods which bring out some one property of an oil more than some other but equally important characteristic (asphalt contents, resins, acid-formation, viscosity); use is made of this specific tendency of an oil to measure the overall stability characteristics in the laboratory.

Since usually all these methods are followed up by a practical motor test, it might have been assumed that despite the many inherent differences in test methods, some comparable results should be obtainable in using some one preferred laboratory method. That this is not the case is already well known for quite a while, and in recent times various authors (Obenaus,[3] Noack,[4] Marder and Tolksmith[5]) have proven convincingly that the known laboratory methods do not yield a comparable picture of the oxidation tendencies of a motor oil. This already becomes clear in working only with one laboratory method, when one attempts to eliminate some one test condition or to alter one of the test variables; it becomes very apparent in such cases that quite different results are obtainable, many of which are entirely contradictory.

Marder and Tolksmith[6] have therefore come to the conclusion that it is not possible to find a laboratory method for determining oxidation tendencies which will give overall reproducible results having a definite significant or chemical basis. They propose therefore to adapt to the laboratory procedure the general conditions which usually prevail in an engine. By doing this though, the wide range of utility of such laboratory ageing tests will be confined to conditions in

some one type of engine, limiting then the value of many oils for other motors of engines.

This proposal appears then to be only a partial solution of the problem; since on the other hand, it is absolutely necessary to have a laboratory ageing test which will give unbiased judgment of this property of motor oils; by such a method the character of the oil is tested, as well as indicating how it can be improved further by controlling the proper refinery operations. This object can only be attained when the laboratory method for ageing tests is not dependent entirely on some on single condition during its use in ageing tests.

Reasons for Limitations of Previous Methods

According to the above five literature references quoted so far, it seemed nevertheless still impossible to find an ideal method. By investigating the methods proposed up to now one finds that the time necessary to effect a certain oxidation of the oil is quite different, not taking into account the conditions of test, and the measurement of the degree of oxidation. One obtains the impression that the prescribed oxidation times were merely selected in order to make the laboratory results consistent or put them in line with results from practical engine tests. In such selection of test conditions resides an inherent error.

In order to obtain comparable results one must subject the oil undergoing oxidation to a certain condition such as exists in a motor, if possible one which would no longer allow the oil to function if it were undergoing a motor test. One must also not push the oxidation so far as to obtain a condition in which the oil has become useless—a fact very necessary to keep in mind. The oxidation tendency of an oil can only be defined by such times which are necessary to arrive at the similar states of oxidation, as measured by some definite value attached to requirement tests such as asphalt formation, resins, acidity, viscosity changes, etc. The similar states of oxidation to be simulated are those formed under certain known and determined conditions existing in the test motor. It stands to reason that actual working conditions and the arbitrary test requirement then play only a minor role as compared to the predetermined theoretical considerations.

This viewpoint has up to now not been kept in mind in considering laboratory test methods so that it does not seem so strange to find wide differences in test methods both for lubricants and for tests used in judging the ageing stability. By a more or less arbitrary determined time of oxidation used in laboratory methods, one obtains oils in any degree or stage of oxidation. This would not be unreasonable were the oxidation of an oil a linear function of time. The researches up to the present[8] however, show that oxidation of oils starts at various times, increases next slowly and then much faster, finally during intensive oxidation proceeding almost linearly with time. One can then only obtain comparative results concerning oxidation or ageing of an oil when one drives the oxidation to the point where the change in the oil varies linearly with time, and noting this initial time period, which is the arbitrary index of measurement of the oxidation of the particular oil.

The Indiana Test

Up to now there is only one method in which the above conditions can be applied—the so-called Indiana Test.[9] In this test the criterion of the ageing test

TABLE 1

Oil No.	NAME	Spec. Grav.	Visc. 20C	Visc. 50C	Pol Height (V. I.)	Acid No.
1	Shell 3X	0.907	713	95	2.42	0.02
2	S. O. Essolub, S.A.E. 40	0.881	430	74	1.97	0.01
3	Gargoyle Mobiloil BB	0.901	773	110	2.11	0.02
4	Pennoil, Ex. medium	0.880	321	62	1.80	0.01
5	Unknown Brand	0.892	735	114	2.10	0.04
6	Essolubrovisol	0.885	342	61	1.98	0.01
7	Neutral-oil; M.-C.	0.897	344	57	2.32	0.04
8	Uspeco, X-med.	0.920	478	62.5	3.05	0.03
9	Bayonne Auto, med.	0.956	662	91	2.40	0.03
10	Atreco motor oil	0.884	287	50	2.30	0.02

of the oil is the time found necessary to produce 100 mgm. of matter insoluble in light petroleum naphtha per 10 gms. of oil. With oils which have an oxidation time greater than 50 hours only the viscosity increase of the oil under test is then recorded. It seemed worthy of test for us to determine whether the Indiana test is also sensitive or highly dependent on variable external conditions in the procedure, as are so many other methods, and we can say, due to our researches, that such is not the case.

The conditions of the Indiana Test are as follows:

Three hundred cc. of oil to be tested are placed in a tall glass tube, allowing 10 litres of air per hour to pass through the oil at 172° C. (thermostat). During regular time intervals 10 gm. of the oil undergoing oxidation are pipetted out for insolubles test in normal benzine. If, after 50 hours, 100 mgm. of insoluble asphalt per 10 gm. oil have not been obtained, then the viscosity of the oil is taken after 50, 100, 150, and 200 hours.

One thus notes that in this test, only one of the oxidation products is quantitatively determined. It is the formation of oil-insoluble matter during oxiadtion of the oil in the motor which causes the greatest operation trouble, while acidity-formation and a renewal of resin formation actually appears to increase the value of well refined oils from an oiliness standpoint, as was recently described by Suida[10] in his work on the processes of oxidation. These oil-soluble oil-resins are also, however, the cause of viscosity increase during oxidation which may disbar the use of many oils in practical motor applications—especially where an oil becomes unduly viscous; at times dilution of such oils with the motor-fuel tends to keep the viscosity down so that here viscosity-increase is not actually noticeable. It appears therefore to be in order to employ the test, as it does, in determining oil-insolubles by precipitation with normal benzine (the asphaltenes) and to record likewise the increase in viscosity from time to time; the increase in acids and esters in the oil, as well as testing for oil-resins (the latter is covered by the viscosity) appears to be of less value for the time being.

Among the factors we desired to investigate as to the conditions of this test was the effect of the

TABLE 2

Oil No.	Glass	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.
1	Duran	71	7.1	95	142.3	114.5	386	145	843
	Jena	71	10.4	95	129.7	114.5	381	145	861
	Thuringian	71	10.2	95	134.2	114.5	412	145	788
2	Duran	91	16.5	114.5	58	140	187	162	256
	Jena	91	13.2	114.5	65.7	140	165	162	277
	Thuringian	91	14.1	114.5	66.8	140	169	162	....
3	Duran	96	....	115	6.8	132	177	145	359
	Jena	96	....	115	6.9	132	161	145	349
	Thuringian	96	....	115	7.4	132	167	145	335

glass on the formation of insoluble matter, and also whether less than 300 cc. of oil would suffice in this test.

It was shown, for oils indicated in Table 1 that in using the standard procedure for the Indiana test the origin of the glass (Duran, Jena, Thuringian, etc.) had no effect on the results obtained. (Table 2.) Since in pipetting a small sample from a large volume oil, homogeneous samples are not always obtained, it would account for the slight discrepancies in results, as are shown in the table. Often the asphalts as they are formed in a far-reaching oxidation, will often settle out at the bottom of the tube, which necessitates stirring the oil thoroughly before and during the sampling.

Since the effect of the glass is nil on the value of the mgms. of insoluble matter, all future oxidations were carried out, therefore, in tubes made of the cheaper and easily obtained Jena glassware.

Further investigations showed also that the Indiana test can be carried out with smaller amounts of oil. Reducing the quantity of oil from 300 cc. to 20 cc. and decreasing the air volume from 10 litres per hour to 650 cc. per hour, all at 172° C., the results are obtained which are well within the error of the test when using 300 cc. of oil. We finally drew up the following procedure, used throughout all future tests:

Modified Indiana Test for Small Amounts of Oil

A thermostatically controlled and electrically-heated oil-bath is held at 172° C.; a recording thermometer gives the 24-hour diagram for temperatures obtained. In this bath are placed Jena glass tubes 30.5 cm long, and 1.8 cm (int.) diameter, containing 20 cc. of the oil to be tested. A stream of air, previously dried, is led into the oil at a constant rate of 650 cc. per hour controlled by a flow meter for air. During regular time intervals about 1 cc. of oil were withdrawn (during the oxidation) by means of a pipette, and the asphalt determined which is insoluble in light naphtha. For the latter, one takes 1 gm. of the test oil, places it in a 50 cc. centrifuge bulb, and 40 cc. normal benzine are added. The mix is stirred, and then allowed to stand several hours. The supernatant benzine solution is poured through a fritted-glass (weighed) crucible, containing glass wool about 5 mm. thick, as a padding. The precipitate is next well mixed with again 40 cc. of normal benzine, and filtered through the crucible. The crucible is well washed three times with benzine, and after drying at 150° C. it is finally weighed.

The insoluble matter (mgm. per 1 gm. of test-oil) is plotted so that the abscissa corresponds to mgm. of insoluble-matter, and the ordinate as the time of oxidation. With this graph one can compute very easily the time it would take to form 10 mgm. of asphalt per 1 gm. of test-oil, which is the value of the oxidation index or "sludging time." The results are shown in Table 3.

TABLE 3

Oil	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.
1	69.5	0.3	76.5	2.5	93.5	10.1	101	18.4	117.5	41.3
2	....	....	93.5	1.1	101	2.9	124.5	9.5	141	16.3
3	....	....	117.5	0.5	124.5	7.8	139	29.7	....	....
4	76.5	1.3	101	4.1	117	7.2	141	12.1	....	....
5	....	....	90	0.9	101	5.2	120	20.0	136	37.4
6	95	1.1	111.5	2.3	120	2.8	136	4.0	160	6.4
7	16	0.4	23	1.9	40	6.4	47.5	8.5	64	13.8
8	23	1.2	40	6.8	48	9.4	64	15.5	....	....
9	61	1.0	23	2.6	40	7.1	48	9.8	64	16.6
10	40	1.2	48	2.3	88	6.5	94	7.2	114.5	11.5

TABLE 4

Oil	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.
1	48	3.9	63.5	29.7	71.5	46.2	....	....	....	....
2	75	1.2	90	9.7	111.5	42.3	....	....	....	....
3	71.5	0.3	90	50.9	....	....	....	....	....	....
4	71.5	3.1	90	13.3	111.5	52.0	....	....	....	....
5	72	0.6	85	7.8	102	41.4	....	....	....	....
6	48	0.7	71.5	2.5	90	5.7	115.	10.1	140	14.4
7	17	4.2	24	8.1	41.5	24.1	....	....	....	....
8	17	7.3	24	12.8	42.5	37.4	....	....	....	....
9	17	5.6	24	9.7	42.5	29.0	....	....	....	....
10	22.5	1.0	41.5	4.5	48	7.4	71.	25.7	....	....

The use of smaller oil volumes for testing has the advantage of working with less oil, which is a saving, as well as affording a great saving in time. The testing error is also much less than with 300 cc. of oil since the oil under oxidation is always much more homogeneous than is the case with the larger volume under test conditions.

Oxidation Tests at Higher Temperatures

We next investigated the effect on the artificial ageing of oils by the Indiana test, of higher temperatures; the object is also to judge all lubricants by this test, as was first pointed out by Marder and Tolkmitt, who used the method of Noack. For this purpose our procedure was therefore to keep all other conditions the same as previously employed in the Indiana test, and to change the temperature to 200° C. in one series of tests and to 240° C. in another series. (See Tables 4 and 5.) Were these results graphed one would obtain curves which become much steeper with oxidation-time than do those resulting from our previously employed low-temperature data. Some of these high-temperature curves are almost vertical after 90-100 hours, showing 50-80 mgm. tar. The relative position of various oils, however, remains the same so that good oils will still appear to show that oxidation proceeds at a slow rate.

TABLE 5

Oil	Hours	Mgm.	Hours	Mgm.	Hours	Mgm.
1	33	5.6	48	52.5	....	....
2	64.5	3.4	77	15.0	92	41.3
3	54	7.7	64.5	46.3	....	....
4	66	5.5	76	20.4	84	53.9
5	64.1	2.5	76	18.4	88	49.0
6	44	1.8	64.5	6.6	88	16.2
7	15	8.5	24.5	30.7	....	....
8	15	14.2	24	42.2	....	....
9	15	10.3	24	32.6	....	....
10	17	5.2	24	8.6	46.5	34.3

One can explain, if necessary, the slight shifting of the tar values obtained at 172° C. as compared with the results at higher temperatures by the fact that the curve for the 10 mgm. standard of some oils does not cut the almost linear curve of the other oils.

To present the data in clearer form, the oils to be tested were grouped according to ageing-times, using values of 1-10, wherein the figure 1 denotes the most resistent oil and 10 the least resistant oil, with its shortest ageing time. The results are shown in Table 6, in which are also the "index-values" which are obtained when one desires to judge the oils by using the 5 mgm. or 15 mgm. index instead of the 10 mgm. value. This table shows also that despite the different oxidation temperatures (172° C., 200° C., and 240° C.) and despite the different tar-value standards (5, 10, and 15 mgm. of asphalt) the valuation of the various oils will remain substantially the same.

Most of the oils, even those showing no great variations, can be graphed and curves obtained if one

TABLE 6

Oil No.	172° C.			200° C.			240° C.		
	5 Mgm.	10 Mgm.	15 Mgm.	5 Mgm.	10 Mgm.	15 Mgm.	5 Mgm.	10 Mgm.	15 Mgm.
1	6	7	7	6	7	7	6	6	6
2	3	3	3	2	2	2	1	2	2
3	2	4	4	5	5	5	5	5	5
4	4	2	2	4	4	3	3	4	4
5	5	6	6	3	3	4	2	3	3
6	1	1	1	1	1	1	4	1	1
7	8	8	8	8	8	8	8	8	8
8	9	9	9	10	10	10	10	10	10
9	10	10	10	9	9	9	9	9	9
10	7	5	5	7	6	6	7	7	7

uses 5 mgm as standard at 172° C., since this standard reflects the condition of the oil oxidizing at the very beginning of the ageing process but here again one must note that the oxidation usually has not yet proceeded linearly. For practical purposes it would therefore appear more feasible to use the 10 mgm or 15 mgm. limits and a higher oxidation temperature than 172° C., say 200° C. and the 15 mgm. standard. This also has the advantage of shortening the time of testing.

The values in Table 6 agree still better when one recalls the ageing times of some groups of oils lay so close together that the values could be exchanged without passing beyond the limits of accuracy. The valuations would then also appear more definite if such oils or all oils under test were grouped according to their sludge values.

Increasing the volume of air from 650 cc. to 1000 cc. per hour does not result in any change in results. One obtains at most only a shortening of the ageing time as shown in Table 7.

TABLE 7

Oil	Hrs.	Mgm.	Hrs.	Mgm	Hrs.	Mgm.	Hrs.	Mgm	Hrs.	Mgm.	Hrs.	Mgm.
1	53	1.2	59	4.4	66	9.3	77	22.5	83	32.1	91	46.1
2	88.5	2.2	95	3.7	109	7.5	114.5	9.6	135	18.2	...	....
3	....	....	....	....	113	2.1	120	7.9	137	47.5	...	....
4	70.5	1.7	77	2.6	93.5	5.9	118.5	10.7	146	17.2	...	....
	77	0.5	84	1.1	93.5	3.6	102	15.1	118	34.3	...	....
	53	0.5	77	1.0	93	2.2	101	3.0	141	7.0	150	8.5
	17	1.2	22	2.7	29.5	5.3	49	13.2	73	24.8	...	....
	20.5	1.7	29.5	5.4	46.1	12.9	53	15.6	69	22.9	...	....
9	15.5	2.1	29.5	6.5	46.1	13.0	53	16.1	77	27.9	...	....
10	24.5	0.0	48.5	2.9	64	4.8	96	9.0	...	....	...	....

These results show, therefore, that a laboratory procedure has been evolved which is very reliable for testing oxidation tendencies of oils if one bears in mind that oxidation is dependent on time, and when sufficient time is given to this oxidation to show up differences in the tar value produced.

So far our work had to do only with the Indiana test. Our results appear to indicate that the conclusions arrived at also apply, no doubt, to other text-oxidation methods. The Indiana test results have to do only with the oxidation tendency of oils. One can, however, pretty well indicate the life or resistance of an oil as shown by this test and predict it will also closely show the same relative resistance or oxidation stability in a motor. Without actually making the engine tests the oil is well judged as to its life by the Indiana test as we have described it. This test is also useful in classifying motor-oils, as to the ease of oxidation of their hydrocarbon groups, and it becomes a valuable index for refining.

While the sludge-formation is the index used, this asphalt formation is, however, not the only change occurring in an oil, namely, we have acidity-formation also taking place, as well as saponifiable matter being formed, and an increase in viscosity occurs also. These tests should also be made as well—especially for highly refined oils, and those made synthetically, as shown below.

Oxidations with Definite Oils and Compounds

The following were tested:

1. Lignite-paraffin
2. Fischer's paraffin—from Kogasin boiling over 300° C.
3. Octadecene
4. Oleyl alcohol
5. Oleic acid
6. A synthetic oil: density 0.861 at 20° C.
   E. at 30° C. = 25
   Vis. P. Ht = 1.9
7. Edeleanu extract from light Rumanian lube stock (after 3% and then twice 2% clay-treated at 70° C.); asphalt was thus removed by clay.
8. Topped Wietzer (Alsace) crude, deasphalted by propane, furfural extracted and then bleached two times with 2% earth at 70° C.

The first four substances did not produce insoluble matter (sludge) at 172° C. for 100 hours oxidation time, using 650 cc. air per hour (modified Indiana test).

The neutralization values showed large increases for the lignite-wax or paraffin as to acids produced as seen in Table 8.

TABLE 8

MATERIAL	Acide or Neutralization Values	
Lignite paraffin	0	12.96
Fischer's Paraffin	0.25	6.36
Octadecene	0	9.65
Oleyl Alcohol	0	1.34

These figures indicate that paraffins are principally easily converted to carboxyllic acids by oxidation—a chemical change made use of in technically producing commercial wax-acids from paraffins.

The oleic acid at the end of 100 hours had solidified into an unctuous mass—soluble in normal benzine only to the extent of 63 percent. The insolubles were not the usual asphalts by insoluble oxidized polymers, lactones, etc.

The synthetic oil had become more viscous after 100 hours without showing any precipitable asphaltic sludge; it is therefore very important to obtain viscosities in the case of these oils. As expected, the Endeleanu extract was not at all stable to oxidation and had been converted to a viscous tar at the end of 48 hours.

Since the hydrocarbons did not form visible sludge insoluble in benzine to any great extent—except at very prolonged oxidation times—we made one more experiment to determine the effect of oil-resins on the oxidation of motor oils. For this purpose a sample of Wietzer oil was dissolved in normal benzine and treated with clay in order to remove oil resins. The resins were extracted from the clay (3 percent by weight obtained) and were used as follows:

0.66 gm. (3.3%) resins were dissolved in 20 cc. synthetic oil, and these three products: (1) Wietzer oil, (2) deresined Wietzer oil, and (3) synthetic lube plus 3.3 percent resin, were tested for oxidation values. (See Table 9.)

TABLE 9

	Hrs.	Mgm.	Hrs.	Mgm.	Hrs.	Mgm.
Wietzer Oil (original)	24	2.4	45	8.4	69	22.2
Wietzer Oil (free of resins)	24	0	47.5	3.1	69	12.5
Syn. Oil Plus Resins	24	2.0	47.5	4.1	77	11.5

This shows that resin removal from the Wietzer oil results in a marked reduction in sludge formation,

and also that the synthetic oil containing the added resins is very much less resistant to oxidation than the original oil. The large oxidation tendency also of the treated Edeleanu extract which still contains some 9.2 percent resins, is to be ascribed less to the content of aromatics than to the appreciable resin content it possesses. It seems, therefore, that ageing tendencies are most dependent or greatly influenced by oil resins present in an oil rather than by the actual hydrocarbon content or series which go to make up a lubricant.

Summary

(1) It was shown that up to the present time no rugged test had been developed for studying oxidation characteristics of motor-oils which would yield reproducible results.

(2) We have indicated that oils can be compared as to their life or resistance to oxidation when instead of oxidizing them all for the same time period, one employs a method wherein an oil is oxidized till it produces a definite or standard amount of some easily determined end-product, as for instance, insoluble sludge. Such conditions are obtained by the so-called "Indiana Life Test" which is described as a new and modified procedure of the original Indiana test; this procedure which we have adopted is to use 20 cc. of oil instead of 300 cc., as in the original test. Then the oil is also subjected to 650 cc. of air per hour at 200° C. The time is then noted which is necessary to produce by oxidation 15 mgm. of insoluble asphalt per gram of oil.

(3) The testing of 10 different oils by the modified Indiana test showed that the sludging time or valuation of these oils is in a wide degree independent of the conditions of temperature and volume of air used.

(4) Several other tests showed that in many cases the viscosity, the acid and saponification values must also be determined besides the insolubles test. We have shown also, in conclusion, the effect on the oxidation of an oil of added oil-resins.

[1] Oel u. Kohle 13, 101 (1937).
[2] A lecture before technologists: Fuel & Oil Technology Society of German Chemists, Frankfort, April 1938.
[3] Angew Chem. 48, 587 (1935).
[4] Oel u. Kohle 13, 959 (1937).
[5] Oel u. Kohle 14, 615, 635 (1938).
[6] l.c.
[7] Obenaus: Footnote 3—Also Barnard: S. A. E. Journal 1937, p. 959.
[8] Barnard: S. A. E. Journal, 1937, p. 959.
[10] Oel u. Kohle 13, 201, (1937).

Use of Additives in Automotive Lubricants

[*Continued from page 60*]

pressing, V.I. improving, and detergent properties.[26] In this connection, it should be noted that multifunctional characteristics are possessed by many of the additives discussed in the preceding pages. Alkyl sulfides and phosphites are antioxidants, reduce bearing corrosion, and enhance "oiliness." Sulfurized fatty oils share these abilities and, in addition, are sometimes claimed to have sludge-dispersing properties. Voltolized hydrocarbons improve V.I., depress pour point, and disperse sludge effectively. Voltolized fatty oils, in addition, increase oiliness and, if sulfurized, may reduce oxidation and bearing corrosion as well.

On reviewing such multifunctional behavior, it appears that most additives which form stable colloidal systems in the lubricating oil (Friedel-Crafts condensation products, voltolized materials, certain cellulose and similar esters, soaps, etc.) may serve more or less effectively as pour depressants, V.I. improvers, and sludge dispersers. Should ester or other polar groupings be present, "oiliness" properties are also obtained, or the material may be reacted with a polarity-imparting agent (e.g., sulfur, chlorine, etc.) to obtain such an effect. The latter agent may in some cases (e.g., sulfur) impart antioxidant characteristics and suppress bearing corrosion. Finally, the introduction of a metal imparts detergent ability. It should, therefore, be perfectly possible to prepare a universal multifunctional additive possessing all the properties listed above as desirable, by working to the general formula:

$$M - A \begin{matrix} F \\ + \\ X \end{matrix} R_n$$

where M represents a suitable metal;
A is a nucleus capable of holding the component parts of the molecule together;
R_n are "solubilizing" groups which impart the desired colloidal characteristics to the compounds;
X represents one or more radicals, substituted in A or R, to provide anticorrosive properties; and
F represents one or more radicals, which may be identical to X, to impart "oiliness" enhancing characteristics.

The chief difficulty to be anticipated in following this prescription is the proportioning of the desired properties to yield a balanced additive. Furthermore, the needs of individual mineral oils and of service in different engines vary, and since fitting a differently proportioned universal additive to each need may be rather difficult, most multifunctional additives will

probably always be employed to obtain the certain properties which they impart most effectively. Other wanted characteristics will be controlled by base stock selection (with reference to crude petroleum source), refining methods, and auxiliary additives.

Future Needs

It appears futile to attempt a forecast of the specific requirements which the future will impose on lube-oil additives, since service requirements will change yearly. Bearing corrosion was practically unknown until the introduction of copper-lead and cadmium-silver bearings made it a serious problem. Piston skirt varnish formation in high-speed passenger car service became troublesome only during the past few years upon the adoption of higher crankcase operating temperatures. The coming years will bring new problems, each placing different and usually greater demands on the lubricant. High viscosity index and low pour point will probably always remain in demand, but the particular degree and form of chemical stability, detergency, oiliness, etc., wanted can hardly be considered fixed. It therefore only appears safe to say that the demand for additives to modify these characteristics will probably increase.

LITERATURE BIBLIOGRAPHY

[1] Blackwood, A. J., S.A.E. Journ. **36,** 70 (Feb., 1935).

[2] Blackwood, A. J., and Rickles, N. H., S.A.E. Journ. **28,** 234 (Feb., 1931).

[3] Bray, U. B., Moore, C. C., and Merrill, D. R., Paper, S.A.E. Meeting, White Sulphur Springs, June, 1938; Oil & Gas J., **37,** No. 5, 47 (June 16, 1938).

[4] Davis, G. H. B., and Zimmer, J. C., Science of Petroleum, p. 2673, Oxford University Press (1938).

[5] Decavel, and Rogiers, M., Chim. et. ind., **25,** 443 (March, 1931, Special Issue); See also Oil & Gas J., **35,** No. 45, 127 (March 25, 1937).

[6] de Hemptinne, A., Bull. soc. chim. belg., **26,** 55 (1912).

[7] Downing, F. B., Holbrook, G. E., and Fuller, J. H., Paper, Petroleum Div., A.C.S., Baltimore, April 3-7, 1939.

[8] Evans, E. A., and Kelman, A. L., Paper, I.M.E. Discussion on Lubricants, Group IV, pp. 90-99 (October 15, 1937); Chem. Trade J. **101,** 365 (1937).

[9] Fenske, M. R., Stevenson, C. E., and Hersh, R. E., Paper, Michigan—Life Conference on New Technologies in Transportation, Ann Arbor, Mich., (November 1, 1939); Nat. Pet. News, **31,** No. 46, R-471.

[10] Foote, P. D., J. Applied Physics **8,** 19 (Jan., 1937).

[11] Gruse, W. A., Proc. World Pet. Congr., London, **2,** 441 (1933).

[12] Gruse, W. A., and Livingstone, J. C., A.S.T.M. Symposium on Lubricants, Chicago (1937) p. 1.

[13] Larson, C. M., Paper, S.A.E. Meeting, Peoria April 21, 1937; S.A.E. Journ., **41,** 547 (Dec., 1937).

[14] Larson, C. M., Paper, S.A.E. Meeting, White Sulphur Springs, June 9-14, 1940; S.A.E. Journ. **47,** No. 1, 62 (July, 1940).

[15] Livingstone, J. C., and Gruse, W. A., Paper, N.P.A. Meeting, State College, Pa. (May 29, 1936); Oil & Gas J. **35,** No. 6, 62 (1936).

[16] Maverick, G. M., Paper, S.A.E. Meeting, Metropolitan Section (March 8, 1937); S.A.E. Journ. **40,** No. 41, 35 (April, 1937).

[17] Maverick, G. M., and Sloane, R. G., A.S.T.M. Symposium on Motor Lubricants, Chicago (1937) pp. 53-74.

[18] Neely, G. L., S.A.E. Journ. **41,** 548 (Dec., 1937).

[19] Neely, G. L., S.A.E. Journ. **45,** 485 (1939).

[20] Otto, M., Miller, F. L., Blackwood, A. J., and Davis, G. H. B., Oil & Gas J., **33,** No. 26, 98 (1934).

[21] Ralston, A. W., Christensen, C. W., Hoffman, E. J., Selby, W. W., and Conquest, V., Nat. Pet. News, **28,** No. 50, 59 (Dec. 9, 1936).

[22] Ralston, A. W., and Hoffman, E. J., **ibid, 31,** No. 16, R-150 (April 19, 1939).

[23] Rosen, C. G. A., S.A.E. Journ., **40,** 165 (1937).

[24] Rosen, C. G. A., Paper, N.P.A. Meeting, Cleveland, April 18, 1940; Nat. Pet. News, **32,** No. 18, R-152 (May 1, 1940).

[25] Round, G. A., Paper, N.P.A. Meeting, Cleveland, April 18-19, 1940; Nat. Pet. News, **32,** No. 18, R-149 (May 1, 1940).

[26] Stewart, J. P., Moran, R. C., and Reiff, O. M., Paper, A.S.T.M. Meeting, Detroit, March 6, 1940; Nat. Pet. News, **33,** No. 12, R-88 (March 20, 1940).

[27] Stewart, J. P., and Story, B. W., Paper, S.A.E. Congress, New York City, May, 1939; Oil & Gas J., **38,** No. 3, 44 (June 1, 1939).

[28] Thomas, R. M., Sparks, W. J., Frolich, P. K., Otto, M., and Mueller-Cunradi M., J.A.C.S., **62,** 276 (1940).

[29] Thomas, R. M., Zimmer, J. C., Turner, L. B., Rosen, R., and Frolich, P. K., Paper, Petroleum Division, A.C.S., Boston Sept. 11-15, 1939.

[30] Vobach, A. C., and Fairlie, M., Proc. 2nd World Pet. Congr., Paris, 1937, **3,** No. 4, 458.

[31] Zimmer, J. C., Davis, G. H. B., and Frolich, P. K., Bull. Mineral Ind. Exp. Sta., Penn State College, **12,** 57 (1933).

PATENT BIBLIOGRAPHY

I. *Viscosity-Index Improvers—*

[32] A. Hydrocarbons—U. S. Patents: 1,998,350, 2,018,871, 2,028,349, 2,072,107, 2,072,120, 2,084,501, 2,106,232, 2,109,772, 2,142,219, 2,142,220, 2,142,327, 2,167,064, 2,197,769.

[33] B. Esters and Ethers — U. S. Patents: 1,882,816, 2,020,703, 2,020,714, 2,031,227, 2,091,627, 2,104,408, 2,104,796, 2,107,316, 2,114,525, 2,123,641, 2,127,811, 2,133,493, 2,138,771, 2,144,773, 2,147,647, 2,152,683, 2,158,389, 2,167,726, 2,173,117, 2,184,957, 2,196,670.

[34] C. Other Agents—U. S. Patents: 66,573, 970,473, 2,025,490, 2,045,922, 2,049,019, 2,078,472, 2,086,399, 2,104,409 2,113,599, 2,132,847, 2,199,352.

II. *Pour Depressors—*

[35] A. Friedel-Crafts Condensation Products of Aromatics and Chlorinated Paraffins — U. S. Patents: 1,815,022, 1,963,917, 2,015,748, 2,030,307, 2,049,058, 2,052,003, 2,057,104, 2,061,008, 2,062,676, 2,062,677, 2,073,080, 2,087,682, 2,113,179, 2,138,809, 2,147,547, 2,174,246, 2,189,924, 2,191,498.

[36] B. Other Condensation Products — U. S. Patents: 2,022,990, 2,033,546, 2,043,836, 2,045,806, 2,062,354, 2,080,088, 2,081,518, 2,106,247, 2,111,769, 2,114,812, 2,121,326, 2,128,109, 2,142,219, 2,142,220, 2,147,315, 2,147,545, 2,147,546, 2,177,923, 2,183,009, 2,204,609.

[37] C. Voltolized Products—U. S. Patents: 2,028,349, 2,073,641, 2,084,352, 2,088,898, 2,140,545, 2,197,769.

[38] D. Soaps—U. S. Patents: 1,594,762, 1,625,969, 1,729,823, 1,752,309, 1,767,076, 1,789,026, 1,804,124, 1,806,734, 1,806,735, 1,837,279, 1,896,342, 1.942.636. 2,055,417, 2,059,192, 2,171,781.

[39] E. Esters—U. S. Patents: 1,929,189, 1,944,164, 2,018,758, 2,031,227, 2,039,111, 2,048,465, 2,048,466, 2,053,853, 2,115,823, 2,119,718, 2,138,771, 2,141,601, 2,157,078, 2,157,079.

[40] F. Other Agents—U. S. Patents: 1,859,692, 1,870,074, 1,917,875, 1,953,039, 1,959,054, 2,040,057, 2,055,482, 2,076,153, 2,138,868, 2,150,156, 2,197,713, 2,197,837, 2,198,293.

III. *Antioxidants and Metal Passifiers—*

[41] A. Phenols—U. S. Patents: 1,793,134, 2,031,930, 2,137,815, 2,145,970, 2,145,971, 2,195,510, 2,202,825.

[42] B. Hydroxy Sulfides—U. S. Patents: 2,085,045, 2,108,954, 2,109,463, 2,139,321. 2,139,766, 2,174,248, 2,198,828.

[43] C. Sulfurized Oils (see also Film Strength Agents—U. S. Patents: 2,113,811, 2,162,398, 2,179,060, 2,179,067.

[44] D. Alkyl Sulfides—U. S. Patents: 2,000,105, 2,028,257, 2,081,886, 2,113,811, 2,153,973, 2,154,628, 2,192,874.

[45] E. Other Sulfur-Containing Compounds—U. S. Patents: 2.096,905, 2.134.432, 2,134,433, 2,139.335, 2,139,758, 2,149,788, 2,161,566, 2,161,583, 2,162,207, 2,169,700, 2,190,648, 2,196,963, 2.204,660.

[46] F. Phosphorus Compounds—U. S. Patents: 2,058,342, 2.058,343, 2.058.344, 2,084,270, 2,101,632, 2,157,479, 2,167,867, 2,169,185, 2,174,019, 2,191,996.

[47] G. Amino Compounds—U. S. Patents: 1,888.023, 1.973,676, 1.988 299, 2,097,162, 2,104,796, 2,113,150, 2,123,457, 2,132,674, 2,167,273, 2,187,353, 2,189.788.

[48] H. Other Nitrogen - Containing Compounds — U. S. Patents: 2,134.306, 2,136.788, 2,139,086, 2,139.087, 2,139,088, 2,139,726, 2,150.400, 2,153.121, 2,154,096, 2,154,097, 2,160.293, 2,160.880, 2,168,674, 2,175,548, 2,178.455, 2,195.167, 2,197,153, 2,198.961. 2,205,172.

[49] I. Organo-Metallic and Other Metallic Compounds—U. S. Patents: 1,857,761, 2,057,212, 2,112,305, 2.125.961, 2,139,725, 2.149.856, 2.150.349, 2,158,668, 2,160.273, 2,160,917, 2.161.184, 2,177,561, 2.181,913, 2,181,914, 2,181,915, 2,187,802. 2,197,832, 2.197.836. 2,198,275, 2.198 292, 2,198,307.

[50] J. Other Agents — U. S. Patents: 2,100,685, 2,115,355, 2,119,114, 2,143,142, 2,178,769, 2,191,090.

IV. *Sludge Dispersers and Detergents—*

[51] A. Condensation and Polymerization Products — U. S. Patents: 2,069.273, 2,069.274, 2,115.354, 2,150,370.

[52] B. Soaps—U. S. Patents: 1,628,646, 1,628,647, 1,888.974. 2 001,108, 2 032 279, 2,059,567, 2,081,075, 2,095,538, 2,125.304, 2,125,934, 2,125,935, 2.125,936, 2.144,078, 2,163.622. 2.171,781, 2,180.697, 2,180,698, 2,180,699, 2.186.346; Brit. Patents: 398,222, 423,441, 431,066, 474,156.

[53] C. Soaps Plus Other Agents—U. S. Patents: 2,147,155, 2,202,826, 2,204,597. 2,204,598. 2,204,601.

[54] D. Metallic Phenolates — U. S. Patents: 2,197,833, 2,197,834, 2,197,835, 2,198,274.

V. *Film Strength Agents—*

[55] A. Oxygen Compounds—U. S. Patents: 2,018,758, 2,049.072, 2,087,603, 2,096.905, 2,106,247, 2,110,078, 2.111,769, 2,113,752, 2,113,754, 2,115,341, 2,121,976, 2,128.574, 2,134,436, 2.134,554, 2,134,736, 2,137,782, 2,143.142, 2,149.857, 2,150,156, 2,158,096, 2,173,117, 2,186,909, 2,186.910, 2,194,478.

[56] B. Sulfur Compounds—U. S. Patents: 1,516,879, 1,590,800, 1,604,068, 1,689,011, 1,812.766, 1,824,523, 1,844,440, 1,929,955, 1,959,054, 1,964,983, 1,971,243, 1,974,299, 1,987,397, 2,020.021, 2,043,961, 2,043,962, 2,048,479, 2.061,019, 2,073.841, 2,096,449, 2,096.905, 2,109,463, 2,109,464, 2,109,692, 2,110,281, 2,111,882, 2,111,990, 2,113.810, 2,113,811, 2,121,151, 2.124,598, 2,133.828, 2,134,432, 2,134,433, 2,134,434, 2.134,435, 2.134.436, 2,141,142, 2,143,512, 2,147,578, 2,151,585, 2,153,482, 2,154,628, 2,156.919, 2,161.566, 2,161,584, 2,161,585, 2,162,398, 2,164,393, 2.167,439, 2,167.612, 2,168,262, 2,168,848, 2,169,700, 2.172,285, 2,176,632, 2,176.633, 2,178.325, 2,179.060-7, 2.181.964, 2,190,648, 2,192,390, 2,193,476, 2.193,771, 2.195.594, 2,197,781, 2,198,562, 2,201.258, 2,201,607, 2,204,660, 2,204,661, 2,205.858, 2,206.245.

[57] C. Phosphorus Compounds — U. S. Patents: 2,005 619, 2,094,202, 2,109,490, 2,109,491, 2,138,835, 2,142,998, 2,146,543, 2,146.584, 2,149.271, 2,151,380, 2,157,452, 2,160,915, 2,176,884, 2,178,610, 2,188,943, 2,190.715.

[58] D. Chlorine Compounds — U. S. Patents: 1,936,670, 1,939,979, 1,939,993, 1,939,994, 1,939,995, 1,944,941, 1,945.615, 1,986,645, 1,986,651, 2,051,744, 2,069,790, 2,074,338, 2,106,554, 2,107,905, 2,109.357, 2.119,556, 2.121,824, 2,121,825, 2,125,169, 2,126,590, 2,137.777, 2,137,782, 2,137,783, 2,137,784, 2,150,079, 2,150,177, 2,155,204, 2,157,078, 2,157.079, 2.157,134, 2.161,560, 2,161,678, 2,162,970, 2,166,286, 2,172.382, 2,178,513, 2,180,008, 2,183,294, 2,186,916, 2,186,917, 2,188,255, 2,202,641, 2,204,620, 2.205,740, 2,206,573.

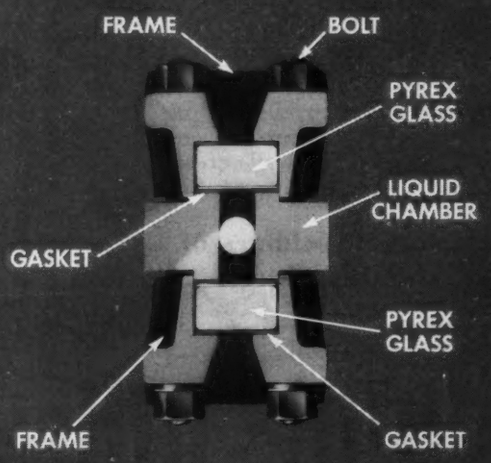
PENBERTHY

DROP FORGED STEEL

TRANSPARENT

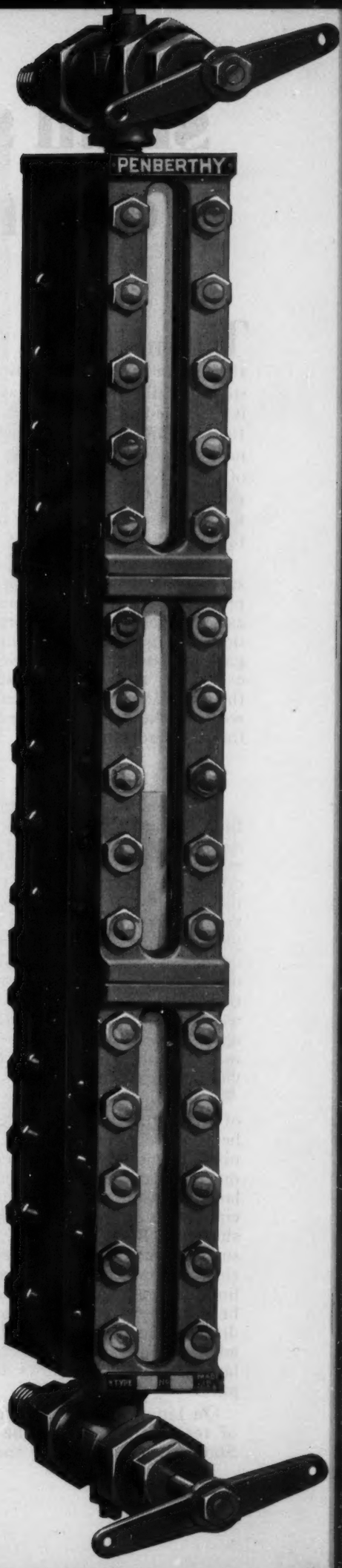
LIQUID LEVEL GAGES

To observe the color or density of liquids under high pressures and/or temperatures



Made of alloy temperature resisting steel. Liquid chamber for single or multiple section gage is made of a solid block of steel the full width of frame to assure perfect alignment and rigidity. Frame has an extra heavy beam at each end and glass chamber is accurately machined to the contour of the glass providing full metal backing for the gaskets. Pyrex glass has greater resistance to thermal shock and erosion.

These gages are available in any length and for various pressures and temperatures. We shall be glad to quote upon your requirements. Write for new Catalog 34-A.



PENBERTHY INJECTOR COMPANY

DETROIT, MICHIGAN

PENBERTHY PRODUCTS

CANADIAN PLANT:
WINDSOR, ONTARIO

Small Stocks of Heavy Fuels Chief Inventory Problem

L. J. LOGAN

THE OIL industry has entered 1941 in an inventory position considerably different from that which it occupied at the beginning of 1940, being concerned primarily now over relatively small stocks of heavy fuel oils, while the fundamental difficulty a year ago was the need for larger stocks of light fuel oils for heating.

The situation of a year ago resulted eventually in emergency production of light fuels and a necessary accompanying overproduction of gasoline. Consequently, gasoline stocks became seriously excessive and the industry all through 1940 was penalized by weak markets and depressed prices for its principal product.

Heating Oils

A lesson was learned from the 1940 situation, and the industry successfully guarded against a repetition of the scarcity of heating oils in the winter of 1940-1941, by taking throughout 1940 increased yields of the light oils and smaller yields of gasoline. Consequently, no serious threat of a shortage of light fuel oil has occurred this winter, particularly with the weather comparatively mild; and worthwhile progress has been made in achieving a better gasoline inventory situation.

Now, however, the old problem of providing enough heating oil has been superseded by that of furnishing enough heavy fuel oil to meet the current and prospective large demand for those oils. Principal users of the heavy oils include shipping lines, railroads, mines, smelters, manufacturing plants, and electric power plants. And all those lines now are and indefinitely will be extremely busy. Consequently, difficulty in supplying all the needed heavy oils is foreseen, particularly inasmuch as stocks are comparatively low.

On January 18, 1941, total stocks of residual fuel oil in the United States were reported by the American Petroleum Institute at 101,213,000 barrels, about 3,000,000 barrels, or 2 percent, less than the 103,905,000 barrels on hand the corresponding date a year ago.

Stocks of Crude and Refined Oils Increased in 1940

(Source: Bureau of Mines)

STOCKS	Barrels on Hand November 30		Percent Change
	1939	1940	
Crude Petroleum:			
Refinable in U. S.	235,291,000	263,163,000	+ 11.8
Heavy in California	13,664,000	12,257,000	— 10.3
Natural Gasoline	4,579,000	6,102,000	+ 33.3
Refined Products	272,354,000	285,302,000	+ 4.7
Total, all oils	525,888,000	566,824,000	+ 7.8
Day's Supply:			
November Basis	129	135	+ 4.6
11-month basis	136	143	+ 5.1

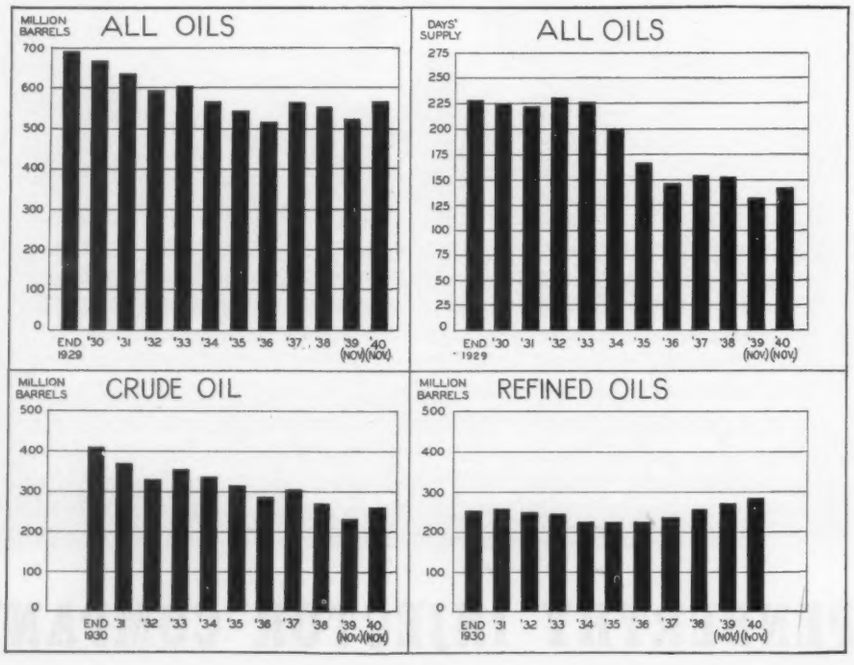
Yet demand for heavy fuel oil already is up substantially from a year ago, and requirements are expected to increase even further. The gain in total demand for that product was 4 percent even in 1940, with domestic consumption up nearly 5 percent and exports down only 6 percent; and a larger gain in domestic and total requirements is indicated for 1941, because of the active business scene that is unfolding.

In its forecast for January, the Bureau of Mines discussed in considerable detail the situation with regard to heavy fuel oils. The agency stated that prospective large demand for the heavy fuels would require increased yields of those oils at the refineries or increased imports, as alternatives to the running of more crude to stills than necessary for supplying other products in sufficient quantities.

"A sharp rise in the demand for residual fuel oils is indicated as defense activities get into full production," stated the bureau. "Residual fuel stocks east of California, although several million barrels above the abnormally low level of last year, appear to be inadequate. As indicated in the December forecast, this situation would require either greater runs than are necessary for other products, increased yields, or larger imports."

So far, the industry has fairly

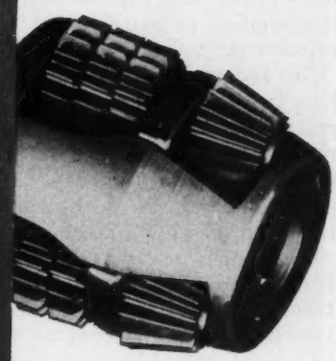
Comparative Volumes of Oil in Storage

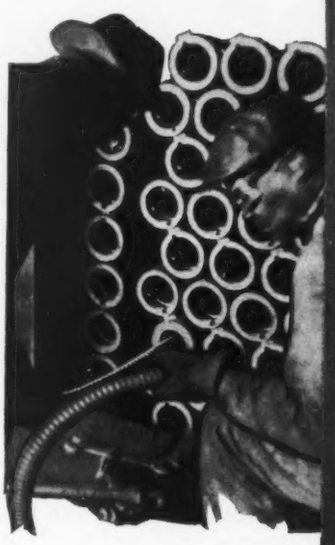


Get tubes cleaned fast with . . .

LAGONDA -LIBERTY

TUBE CLEANERS





Don't dilly-dally over tubes coated with profit-eating coke. Jump into action with fast, powerful Lagonda-Liberty cleaners that drive through the toughest, hardest deposits with the speed and ruggedness of a champion! And reduce "down time" records to the roots!

These cleaners have the stuff to get your stills back on stream in the fastest possible time. And a record of refinery service that dates back to the first tube still.

There's a Lagonda-Liberty Tube Cleaner for every type of coke deposit and every size of tube.

WRITE FOR THIS BOOK NOW and get the facts on refinery tube cleaning.

ELLIOTT COMPANY

LAGONDA-LIBERTY Tube Cleaner Dept.

SPRINGFIELD, OHIO

District Offices in Principal Cities

Y-160

well avoided taking the least desirable of the three courses, that of stepping up refinery runs to high levels at the expense of damaging the gasoline-inventory position. Instead, both the other possible solutions have been used to some extent. The industry has increased yields of the heavy fuel oils and also has brought in larger quantities of crude and fuel oil from South America, under the Venezuelan agreement, which permits crude and fuel-oil imports up to specified proportions at half the regular tax rates.

In recent months the industry has been taking at the refineries relatively low yields of gasoline, normal yields of light fuel oils, and increased yields of residual fuels; and continuance of that policy in the months ahead is indicated.

Although heavy fuel oils constitute a very substantial part of the total volumes of oil marketed by the industry, gasoline still is the principal refined product and the one around which operations are determined. Encouraging have been the results so far, therefore, in improving the gasoline inventory situation, although the markets do not yet reflect the progress that has been made.

Stocks of All Products Except Heavy Fuels and Road Oil Larger Than Year Ago

(Source: Bureau of Mines)

PRODUCT	Barrels on Hand November 30		Percent Change
	1939	1940	
Gasoline:			
Finished	71,619,000	73,429,000	+ 2.5
Unfinished	5,171,000	6,088,000	+ 17.7
Total	76,790,000	79,517,000	+ 3.5
Aviation Gasoline	2,526,000	6,206,000	+145.7
Kerosene	9,019,000	10,473,000	+ 16.1
Gas Oil & Distillate Fuels:			
Refinery	30,179,000	35,885,000	+ 18.9
Bulk Terminal	7,709,000	10,739,000	+ 39.3
Total	37,888,000	56,624,000	+ 49.4
Residual Fuel Oils:			
Refinery	91,466,000	85,334,000	— 6.7
Bulk Terminal	5,230,000	7,058,000	+ 34.8
Total	96,696,000	92,392,000	— 4.4
Lubricants	6,799,000	8,365,000	+ 23.0
Wax (pounds)	81,369,000	120,212,000	+ 47.7
Coke (short tons)	647,000,000	527,000,000	+ 18.5
Asphalt (short tons)	497,000,000	526,000,000	+ 5.8
Road Oil	654,000	570,000	— 12.8
Miscellaneous	302,000	352,000	+ 16.5
Other Unfinished Oils	37,947,000	41,052,000	+ 8.2

Crude Stocks Larger Than Year Ago in All but Few Districts

(Source: Bureau of Mines)

	BARRELS ON HAND NOVEMBER 30		Percent Change
	1939	1940	
At Refineries by Location:			
East Coast:			
Domestic	9,512,000	11,191,000	+ 17.6
Foreign	2,600,000	2,299,000	— 11.6
Appalachian	949,000	923,000	— 2.7
Indiana, Illinois, Kentucky, Michigan	4,738,000	5,679,000	+ 19.8
Oklahoma, Kansas and Missouri	3,565,000	3,951,000	+ 10.8
Texas:			
Inland	1,335,000	1,431,000	+ 7.2
Gulf Coast:			
Domestic	12,111,000	12,164,000	+ 00.4
Foreign	15,000	353,000	+2253.0
Louisiana Gulf Coast:			
Domestic	1,713,000	4,040,000	+ 135.8
Foreign	295,000	98,000	— 66.8
Arkansas, Inland Louisiana, Mississippi	906,000	827,000	— 8.7
Rocky Mountain	1,841,000	2,044,000	+ 11.0
California	9,581,000	7,962,000	— 16.9
Total	49,161,000	52,962,000	+ 7.7
At Refineries by Origin:			
Pennsylvania Grade	524,000	504,000	— 3.8
Other Appalachian (including Kentucky)	417,000	425,000	+ 1.9
Lima-Northeast Indiana-Michigan	824,000	493,000	— 40.2
Illinois-Southwest Indiana	1,900,000	2,933,000	+ 54.4
North Louisiana, Arkansas, Mississippi	2,013,000	3,665,000	+ 82.1
West Texas and Southeast New Mexico	4,738,000	5,746,000	+ 21.3
East Texas	3,786,000	4,028,000	+ 6.4
Oklahoma, Kansas, North Texas, etc.	11,662,000	12,177,000	+ 4.4
Gulf Coast	8,715,000	10,180,000	+ 16.8
Rocky Mountain	1,938,000	1,972,000	+ 1.7
California	9,734,000	8,089,000	— 16.9
Foreign	2,910,000	2,750,000	— 5.5
Total	49,161,000	52,962,000	+ 7.7
Pipe-Line and Tank-Farm:			
Pennsylvania Grade	3,990,000	3,560,000	— 10.0
Other Appalachian (including Kentucky)	904,000	879,000	— 2.8
Lima-Northeast Indiana-Michigan	746,000	663,000	— 11.1
Illinois-Southwest Indiana	14,612,000	16,874,000	+ 15.5
North Louisiana, Arkansas, Mississippi	3,979,000	5,153,000	+ 29.5
West Texas and Southeast New Mexico	14,997,000	19,426,000	+ 29.5
East Texas	10,237,000	14,532,000	+ 41.9
Oklahoma, Kansas, North Texas, etc.	73,460,000	83,699,000	+ 13.9
Gulf Coast	14,022,000	17,890,000	+ 27.6
Rocky Mountain	15,282,000	13,096,000	— 14.3
California	21,769,000	23,291,000	+ 6.9
Total	173,998,000	199,063,000	+ 14.4
Lease (Producers) stocks*	12,132,000	11,138,000	— 8.2
Total Refinable Crude in the United States	235,291,000	263,163,000	+ 11.8

* November 30, Pennsylvania Grade, 320; other Appalachian, 70; Lima, etc., 130; Illinois-Southwest Indiana, 440; North Louisiana-Arkansas-Mississippi, 475; West Texas-Southeast New Mexico, 1,025; East Texas, 865; Oklahoma-Kansas, etc. 2,680; Gulf Coast, 970; Rocky Mountain, 500; California, 3,663.

In the early part of 1940, gasoline stocks reached an all-time high of over 103,000,000 barrels, while demand was not up proportionally; with the result that the gasoline market became extremely unstable. However, unusually good domestic demand more than offset loss of export business, and as demand continued on the gradual uptrend, the gasoline stocks in 1940 came to be less and less out of line with market requirements. Thus in terms of days' supply at prevailing rates of consumption, the gasoline stocks were far higher in early 1940 than a year previously; not that much above the year-ago trend at mid-year; and no greater at the close of 1940 than at the close of 1939.

Gasoline stocks are due to continue increasing until spring, but it currently is indicated that they may be several millions of barrels under last year's peak when they reach their high around March 31, 1941. The Bureau of Mines stated that a normal increase of at least 14,000,000 barrels seemed unavoidable for the first quarter of 1941. The bureau foresaw, therefore, a peak of at least 96,000,000 barrels for March 31, 1941, as compared with almost 104,000,000 barrels at the corresponding time in 1940. That indicated stock position would represent a material improvement, the agency pointed out, because of an expected increase of 6 to 7 percent in domestic motor fuel demand during 1941 and also because the figure would include an increase of several million barrels in essential aviation gasoline stocks.

Total stocks of finished and unfinished gasoline in the United States amounted to 87,351,000 barrels on January 18, 1941, the American Petroleum Institute reported, as compared with 87,574,000 barrels January 18, 1940, the curve for 1941 having dipped during the week below that for 1940.

Stocks of light fuel oils remain adequate in relation to prevailing demand. They totaled 39,920,000 barrels on January 18, 1941, according to the American Petroleum Institute, as against 29,505,000 barrels a year previously. That gain over a year ago amply takes care of the material gain which has occurred in demand for the light oils. Total demand for gas oil and distillate fuel was 10.6 percent larger in the first 11 months of 1940 than in the corresponding months a year earlier.

NICKEL ALLOY STEELS

Cast from Nickel alloy steel by the Sivyer Steel Casting Co., Milwaukee, the floating tube heads pictured above are being pressure tested. Nickel alloy steels retain strength and toughness from below minus 100 degrees Fahrenheit to above 1000 degrees. Furthermore, the low creep rate of Nickel-chromium-molybdenum steels and certain other nickel alloy steels is an added advantage in refinery applications involving high temperatures. These Nickel-chromium-molybdenum steel castings will be used in refinery service to withstand 1000 lbs. pressures and 1000 degrees F. temperatures.

NICKEL STEELS...
widely used for these Refinery Applications:

EXCHANGERS	VALVE BODIES	STRESSED BOLTS
CONDENSERS	PRESSURE VESSELS	PIPING CORROSIVES
COOLERS	RETURN BENDS	DEWAXERS
	TUBE SUPPORTS	

• Whether your problem is corrosion, breakage or temperture extremes, your consultation is invited on refinery applications best served by materials containing Nickel.

Dense-grained, uniformly pressure-tight, these high-strength Nickel alloy steel castings permit simplified design. One casting replaces eight pieces required with former types of construction. Tests on a typical heat showed a tensile strength of 106,750 lbs. per sq. in. (elongation in 2", 22%). Refiners specify metals strengthened and toughened with Nickel to assure longer, improved service life in their equipment.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

Larger Oil Demand Foreseen Despite Lower Exports

DESPITE the shriveling effect of the European war on exports, the petroleum industry of the United States is generally expected to encounter in 1941 the greatest total demand for its products in all history.

Most of the products will be absorbed by the markets in larger quantities, it is indicated, and although the gains for different items will vary, an over-all increase of at least 6 percent is anticipated.

Increase Foreseen

Such an estimate was embodied by the Bureau of Mines in its forecast of requirements in January. The bureau pointed out that it was necessary to consider the probable demand for all oils during the coming year in order to secure the proper perspective for a reasonable forecast of operations for the first quarter. And it stated, accordingly, that an increase of 8 percent in the daily average demand for all oils in 1941, including special defense requirements and stocks, seemed a reasonable and conservative assumption, assuming no drastic changes in international relations. Such a gain would constitute an actual increase of about 102,000,000 barrels for the year. It was conceded, however, that a further loss in exports might reduce that figure to a 6-percent increase in the total demand for all oils, a gain of about 87,000,000 barrels in 1941 over 1940.

Increases over 1940 will differ considerably, however, for the several quarters of this year. Because of the abnormally high demand in the initial quarter of 1940, the increase for the first three months of 1941 may be below the estimated average gain for the year. But the relative increases in subsequent quarters would be progressively greater.

Gasoline Demand

Total demand for petroleum usually varies from year to year in approximately the same percentage as gasoline, the principal product. But the overall gain for 1941 may be a little greater than that for gasoline because of the indicated large increases in requirements of both heavy and light fuel oils.

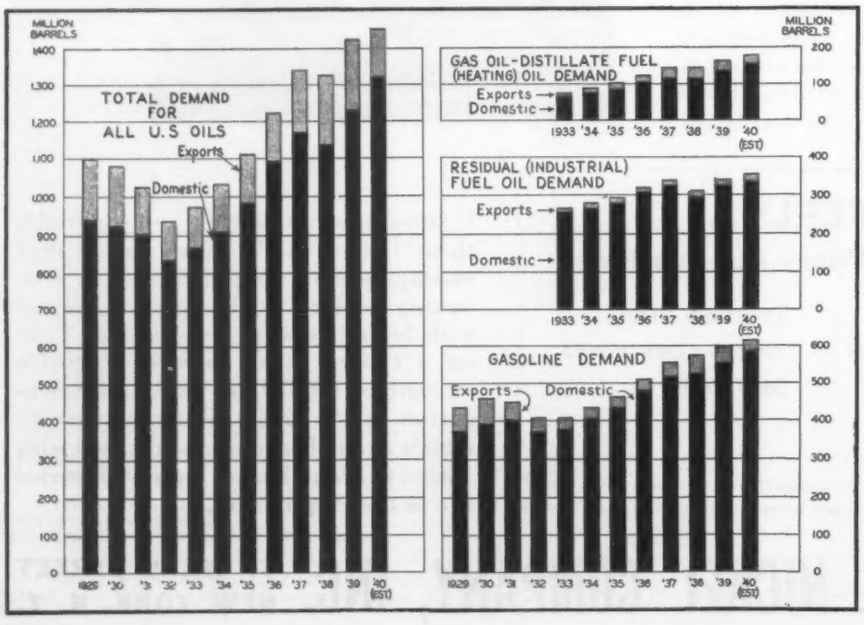
When averaged out, estimates that have been made by approximately a dozen economists foretell an increase of 5.6 percent in total demand for gasoline in 1941. Those forecasts indicate a gain of 6.5 percent in domestic consumption, but a further decrease of 15 percent (3,500,000 barrels) in exports. The average estimate on total demand for 1941 was 646,000,000 barrels, consisting of 625,000,000 barrels of domestic consumption and 21,000,000 barrels of exports.

An increase of over 5 percent in gasoline demand appears certain, in view of the promising automotive outlook. Automobile manufacturers expect to produce and market at least 10 percent more new cars and trucks in 1941 than in 1940 and thereby make a record exceeded only in two previous years, 1929 and 1937. Consequently, a further net gain in automobile registrations is in prospect for 1941, following the setting of new records in 1940. It may be assumed, moreover, in view of the prevailing and prospective high levels of business activity, that there will be this year a continuance of the usual increase in annual consumption of gasoline per vehicle.

Domestic demand for gasoline was approximately 6 percent larger in 1940 than in 1939, having made the same material gain as that for 1939 over 1938. However, exports of gasoline were only a little over one half as large in 1940 as in the previous year, a decrease of 44 percent (18,000,000 barrels) having been recorded for the first 11 months. Consequently, total demand for gasoline showed a gain of only about 2 percent for 1940 as compared with 1939.

A material further increase in demand for residual fuel oil is indicated for 1941 by the general business outlook. Consumption of heavy fuel oil is determined by general industrial and commercial activity, as the heavy fuel is used largely by factories, railroads,

Consumption in 1940 Reaches Record Levels


MILLION BARRELS
TOTAL DEMAND FOR ALL U.S OILS
Exports
Domestic
GAS OIL-DISTILLATE FUEL (HEATING) OIL DEMAND
RESIDUAL (INDUSTRIAL) FUEL OIL DEMAND
GASOLINE DEMAND
1925 '30 '31 '32 '33 '34 '35 '36 '37 '38 '39 '40 (EST)

A CONSTRUCTION METHOD that fits your policies

UNDIVIDED RESPONSIBILITY IN ONE ORGANIZATION

ARTHUR G. McKEE & COMPANY will meet the construction requirements of your refinery without disturbing the reciprocity policies of your business.

Because this company manufactures no refinery equipment, it is in a position to incorporate in the design of your plant any type of equipment your policies dictate. This method of operation permits us to select from the entire field the equipment and supplies which will be of greatest advantage to your business.

The broad scope and long experience of this organization enables us to handle any part of your construction program, or the entire project from economic studies to completion ready for operation.

The McKee Method places undivided responsibility on this organization and protects you with a single lump sum contract. This contract gives you accurate foreknowledge of construction cost, completion date and all other necessary details of the project.

In the hands of McKee experts your refinery program progresses rapidly and efficiently to completion in a minimum of time.

ARTHUR G. McKEE & COMPANY

Engineers and Contractors

2422 EUCLID AVENUE • CLEVELAND, OHIO

30 ROCKEFELLER PLAZA, NEW YORK, N. Y. • BUSH HOUSE, ALDWYCH, LONDON, W. C. 2, ENGLAND

ships, and electric power plants. All those lines of industry are exceptionally busy and will continue so throughout 1941 and longer, because of the national defense program. It appears certain, therefore, that demand for residual fuel oil will break all previous records in 1941, just as it rose to a new high even in 1940.

Domestic demand for residual fuel oil was 4.7 percent larger in the first 11 months of 1940 than in the corresponding months of 1939, and despite a million-barrel, or 6 percent, decrease in exports, total demand showed a 4.1 percent gain.

Consumption of light fuel oil has been increasing sharply and steadily since the depression period, and following the reaching of a new peak in 1940, a further climb into new high ground is indicated for this year. The light fuel oils are used largely for heating, and although more oil burners are in use now than ever before, additional burners continue to be installed in large numbers. Manufacturers of oil burners are extremely optimistic over prospects for sales in 1941, after having sold more burners in 1940 than in any previous year. Estimated sales of 285,000 home oil burners in 1940 compared with sales of 240,000 in 1939; 157,000 in 1938; and 202,000 in 1937.

An increase in building of new homes is anticipated for 1941, and an acceleration of modernization of existing homes is expected. Consequently, oil burner manufacturers feel confident that they will sell even more units in 1941 than the record number of 1940.

Domestic demand for light fuel oil was 10.6 percent (23,000,000 barrels) larger in the first 11 months of 1940 than in the corresponding months of 1939. And that gain was only partially canceled by the decrease of 39 percent (12,000,000 barrels) in exports. Consequently, total demand showed an increase of 7.3 percent (11,000,000 barrels) for the 11 months.

Consumption of kerosene may not increase in proportion to the gains for some of the other products, as the agricultural part of the population probably will feel only indirectly the business boom generated by the national defense program. However, some further expansion of kerosene demand may be expected, following the material gains of the past year.

Lubricants will be needed in relatively large quantities throughout 1941, because of the exceptionally heavy requirements of mills and factories. And substantial gains over the comparatively light demands of 1940 should be shown. Domestic consumption was up 3.9 percent for the first 11 months of the past year, but exports were down 6 percent, and the gain in total demand was only 7/10 of 1 percent.

Oil Exports Down About One Third in 1940

(Figures indicate barrels, and are from Bureau of Mines.)

ITEM	MONTH OF NOVEMBER 1939	MONTH OF NOVEMBER 1940	MONTH OF NOVEMBER Percent Change	FIRST ELEVEN MONTHS 1939	FIRST ELEVEN MONTHS 1940	FIRST ELEVEN MONTHS Percent Change
Crude Oil	5,323,000	3,805,000	— 28.5	67,420,000	49,526,000	— 26.5
Products:						
Motor Fuel*	2,560,000	2,205,000	— 13.9	41,502,000	23,124,000	— 44.3
Aviation Gasoline (included above)	274,000	†535,000	+ 95.2	3,862,000	3,798,000	— 1.7
Kerosene	567,000	190,000	— 66.5	7,589,000	3,258,000	— 57.1
Gas Oil and Distillate	2,116,000	1,284,000	— 39.3	30,022,000	18,219,000	— 39.3
Residual Fuel Oil	1,116,000	1,334,000	+ 19.5	16,165,000	15,164,000	— 6.2
Lubricants	1,190,000	671,000	— 43.6	10,571,000	9,945,000	— 5.9
Wax (pounds)	12,372,000	11,457,000	— 7.4	218,061,000	181,287,000	— 16.9
Coke (short tons)	38,500,000	42,800,000	+ 11.2	273,600	276,400	+ 10.2
Asphalt (short tons)	2,300,000	14,900,000	+ 547.8	40,200	268,100	+ 566.9
Miscellaneous Oils	18,000	63,000	+ 250.0	109,000	897,000	+ 722.9
‡Total Refined Products	7,817,000	6,084,000	— 22.2	108,326,000	74,111,000	— 31.6
Total Crude and Products	13,140,000	9,889,000	— 24.7	175,746,000	123,637,000	— 29.6

* Includes benzol, 1,000 barrels in November, 1940. † Includes 178,000 barrels anti-knock compounds.
‡ Not the sum of the above figures, some of which do not indicate barrels.

Total Demand for Petroleum Reaches New Peak in 1940, as Material Gain in Domestic Consumption More than Offsets Sharp Decrease of Exports

(Figures indicate barrels, and are from Bureau of Mines.)

SUMMARY	NOVEMBER 1939	NOVEMBER 1940	NOVEMBER Percent Change	FIRST ELEVEN MONTHS 1939	FIRST ELEVEN MONTHS 1940	FIRST ELEVEN MONTHS Percent Change
Total Demand	122,665,000	125,847,000	+ 2.6	1,296,096,000	1,326,722,000	+ 2.3
Daily Average	4,089,000	4,195,000	+ 2.6	3,881,000	3,960,000	+ 2.0
Exports:						
Crude Petroleum	5,323,000	3,805,000	— 28.5	67,420,000	49,526,000	— 26.5
Refined Products	7,817,000	†6,084,000	— 22.2	108,326,000	74,111,000	— 31.6
Total Exports	13,140,000	9,889,000	— 24.7	175,746,000	123,637,000	— 29.7
Domestic Demand:						
Total Domestic Demand	109,525,000	115,958,000	+ 5.9	1,120,350,000	1,203,085,000	+ 7.4
Daily Average	3,651,000	3,865,000	+ 5.9	3,354,000	3,591,000	+ 7.0
TOTAL DEMAND FOR PRODUCTS						
Motor Fuel:						
Domestic	47,407,000	49,074,000	+ 3.5	511,702,000	543,011,000	+ 6.1
Exports	2,560,000	2,205,000	— 13.9	41,502,000	23,124,000	— 44.3
Total	49,967,000	51,279,000	+ 2.6	553,204,000	566,135,000	+ 2.3
Aviation Gasoline: (included above)						
Domestic	411,000	443,000	+ 7.8	*	4,874,000	*
Exports	274,000	535,000	+ 95.3	3,862,000	3,798,000	— 1.7
Total	685,000	978,000	+ 42.8	*	8,672,000	*
Kerosene:						
Domestic	6,023,000	6,768,000	+ 12.4	53,890,000	60,968,000	+ 13.1
Exports	567,000	190,000	— 66.5	7,589,000	3,258,000	— 57.1
Total	6,590,000	6,958,000	+ 5.6	61,479,000	64,226,000	+ 4.5
Gas Oils and Distillate Fuels:						
Domestic	14,417,000	17,135,000	+ 18.9	121,555,000	144,456,000	+ 10.6
Exports	2,116,000	1,284,000	— 39.3	30,022,000	18,219,000	— 39.3
Total	16,533,000	18,419,000	+ 11.4	151,577,000	162,675,000	+ 7.3
Residual Fuel Oils:						
Domestic	29,453,000	29,693,000	+ 0.8	288,476,000	301,990,000	+ 4.7
Exports	1,116,000	1,334,000	+ 19.5	16,165,000	15,164,000	— 6.2
Total	30,569,000	31,027,000	+ 1.5	304,641,000	317,154,000	+ 4.1
Lubricants:						
Domestic	1,927,000	2,449,000	+ 27.1	21,888,000	22,743,000	+ 3.9
Exports	1,190,000	671,000	— 43.6	10,571,000	9,945,000	— 5.9
Total	3,117,000	3,120,000	+ 0.1	32,459,000	32,688,000	+ 0.7
Wax: (Pounds)						
Domestic	38,849,000	30,662,000	— 21.1	281,490,000	325,115,000	+ 15.5
Exports	12,372,000	11,457,000	— 7.4	218,061,000	181,287,000	— 16.9
Total	51,221,000	42,119,000	— 17.8	499,551,000	506,402,000	+ 1.4
Coke: (short tons)						
Domestic	125,700	99,600	— 20.8	1,298,100	1,263,000	— 2.7
Exports	38,500	42,800	+ 11.2	273,600	276,400	+ 1.0
Total	164,000	142,400	— 13.3	1,571,700	1,539,400	— 2.1
Asphalt: (short tons)						
Domestic	367,500	325,400	— 11.5	4,669,100	4,884,900	+ 4.6
Exports	2,300	14,900	+547.8	40,200	268,100	+566.9
Total	369,800	340,300	— 8.0	4,709,300	5,153,000	+ 9.4
Road Oil:						
Domestic	212,000	298,000	+ 40.6	7,775,000	7,678,000	— 1.2
Miscellaneous:						
Domestic	167,000	188,000	+ 12.6	2,017,000	1,956,000	— 3.0
Exports	18,000	63,000	+250.0	109,000	897,000	+722.9
Total	185,000	251,000	+ 35.7	2,126,000	2,853,000	+ 34.2

* Not available. † Exclusive of 15,000 barrels exported from non-contiguous territories but inclusive of 807,000 barrels shipped from U. S. to territories.

Upward Trend in Earnings Forecast for 1941

JOHN E. ARENS
Petroleum Editor, Standard Statistics Company, Inc.

THE American petroleum industry has entered 1941 faced with both major uncertainties and the prospect of relatively favorable operations. Virtually all records in production, manufacturing, and consumption promise to be broken, while the industry hovers closer to the brink of bureaucratic control by the federal government than before.

Because of the uncertainties in the picture and the influence of the United States' steadily accelerating defense program, earnings forecasts are unusually hazardous, but there is good reason to believe that oil companies generally in 1941 will equal and possibly better the relatively good showing of 1940. With gasoline prices currently close to a seven-year low, profits in the first few months will make a poor comparison with a year before, but it is clear that the trend during 1941 will be upward.

This will be in marked contrast to the experience of last year, when a steady downtrend was recorded. An abortive rise in prices following the outbreak of war in anticipation of war oil demand permitted profits in the first part of 1940 to soar. But when exports declined and the excessive level of gasoline inventories became fully apparent, the price structure gradually crumbled, and earnings declined. As a result, the sharp year-to-year improvement of the first nine months is believed to have been largely offset by the poor fourth quarter comparison, and it is estimated that full year 1940 earnings were only about 8 to 10 percent above 1939.

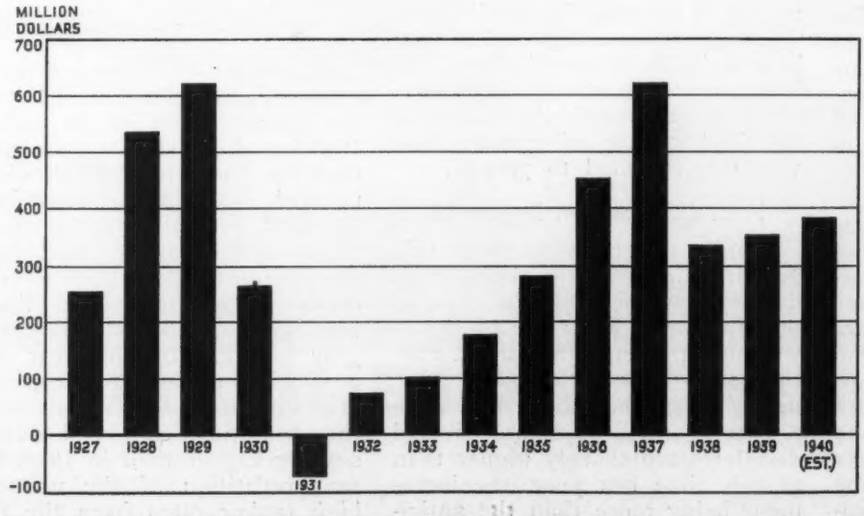
Record Demand in Sight

The prospect of the highest petroleum consumption in history is an important factor in the anticipated reversal of last year's earnings downtrend. Because of the unprecedented national defense spending, demand estimates for 1941 vary widely, but all indicate worthwhile gains for all major petroleum products. The showing in the early months of 1941 will probably be less satisfactory than for the year as a whole, as exports in the first part of 1940 were somewhat above current levels.

Unfortunately for the oil industry, favorable demand is not always synonymous with favorable profits, as the experience of the last few years has amply demonstrated. In fact, it is not uncommon for product prices and oil company earnings to decline in the face of new demand records. The explanation, of course, lies in the inherent difficulty in refining—the problem of maintaining a balanced supply and demand position for each important product and a balance between the different products. The inability of oil companies to act concertedly toward a solution of this problem under our anti-trust laws is a complicating factor.

Statistical Position Improving

With this consideration in mind, an examination of the industry's statistical position at the beginning of 1941 is of considerable interest. Following additions of some 24,000,000 barrels during 1940, crude-oil inventories have been stabilized at around the 262,000,000-barrel level, which is considered to be not far above normal working requirements. Part of the 1940 increment represents the replenishment of stocks depleted by the 15-day shutdown of producing wells in six states in August, 1939, and the



Net Income of 28 Oil Producing and Refining Companies

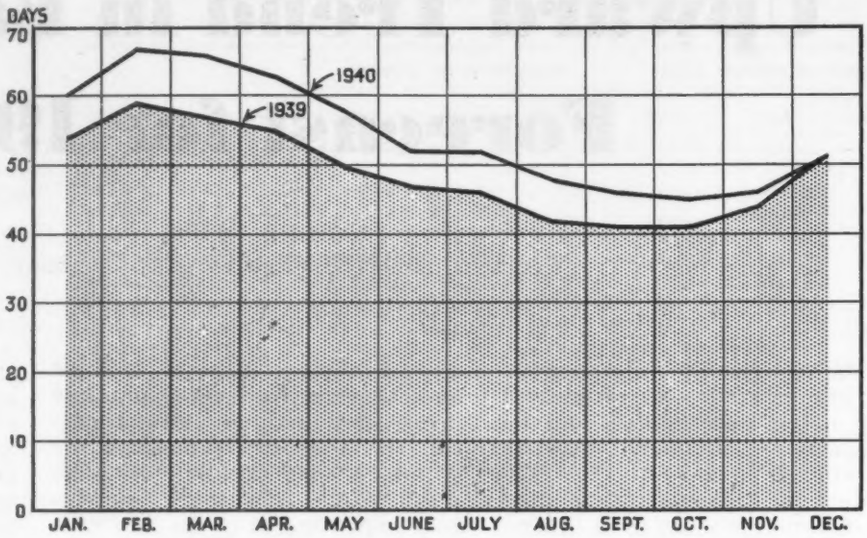
	Net Income (Millions of Dollars)
1940	*382.0
1939	352.3
1938	334.7
1937	621.7
1936	451.2
1935	282.0
1934	179.8
1933	101.4
1932	72.8
1931	†72.7
1930	265.1
1929	621.0
1928	537.7
1927	255.1

* Estimated. † Deficit.

Days' Supply of Motor Fuel in Storage

	1939	1940
January	54	60
February	59	67
March	57	66
April	55	63
May	50	58
June	47	52
July	46	52
August	42	48
September	41	46
October	41	45
November	44	
December	51	*51

* Estimated.
Computed by Standard Statistics Company.



recent stabilization reflects chiefly the decline in unprorated Illinois production.

Far more important from the standpoint of oil profits, however, is the situation with respect to inventories of gasoline, the principal petroleum product. Unsatisfactory gasoline prices, more than anything else, have prevented the industry from capitalizing fully on its favorable demand factors. Stocks of this product currently are about 1,000,000 barrels greater than a year ago, an amount which is considered to be above economic levels. That this amount is excessive, despite the prospective increase in demand, is clearly indicated by the fact that gasoline prices recorded a steady downtrend last year, which terminated at the lowest level attained in about seven years.

A mere glance at the present situation, however, is apt to be misleading, as it ignores the distinctly favorable statistical trends which have been taking place in recent months. The present increment in gasoline inventories over a year ago of about 1,000,000 barrels compares with 11,000,000 barrels on September 30, last.

This considerable relative improvement reflects a combination of favorable demand, fairly well controlled refining operations, and reduced gasoline yields from crude oil, which has permitted gasoline stocks to expand far less since September 30, the end of the heavy consuming season, than in the year-earlier period. Reference to the accompanying chart of gasoline inventories in terms of days' supply shows that stocks on December 1, 1940, were no greater in relation to demand than a year before.

This rate of year-to-year improvement no doubt will not be fully maintained for the first three months of 1941, as gasoline production was sharply curtailed during this period of 1940. The average gasoline yield from crude oil of about 43 percent for the first quarter last year is close to the practical minimum under current operating conditions, and there is little basis for believing that runs to stills will be curtailed below the 3,500,000 barrels daily average of that period.

Nevertheless, the anticipated increase in demand for motor fuel should be reflected in smaller additions to storage over the remainder of the winter, and it is tentatively estimated that stocks on hand next April 1, the beginning of the heavy consuming season, will be in the neighborhood of 98,000,000 barrels, or almost 6,000,000 barrels below a year before. The improvement in terms of days' supply will be greater by reason of the higher rate of consumption which is expected to prevail.

Fuel Oil Position Improved

Closely interwoven with this gasoline picture is the supply-and-demand position of the fuel oils, as one product cannot be produced without producing the others. Fortunately, these factors are more nearly in balance than they were a year ago. Stocks of gas oil and distillates are sharply higher than at this time last year, the increment being more than the anticipated increase in demand over the remainder of the winter. Consequently, the amount of heating oil to be supplied from the refining of crude oil during this period is no greater than in the corresponding 1940 period, and no unusual stimulus to refining operations should arise from this source.

The situation with respect to residual fuel oil is less satisfactory. Inventories were abnormally low a year ago and are moderately lower now, while demand is likely to rise as defense production gets into full swing. This situation probably will require either greater crude runs to stills than are necessary for other products, larger yields of residual fuel oil, or an increase in imports. The solution of this problem may have some bearing on the level of refinery operations and on the trend of gasoline inventories over coming months.

Rising Prices Expected

All things considered, however, it appears that the decline in gasoline prices which set in early in 1940 has about run its course, and that the trend in 1941 should be upward. Sharp improvement is not expected over the near term, because indications are that motor fuel supplies will continue to be excessive for some time, even though they show improvement over the year before. For the year as a whole, it is estimated that gasoline prices in the Mid-Continent and on the Atlantic Coast will average slightly higher than in 1940. Current repetition of the unusually high tanker rates from the Gulf,

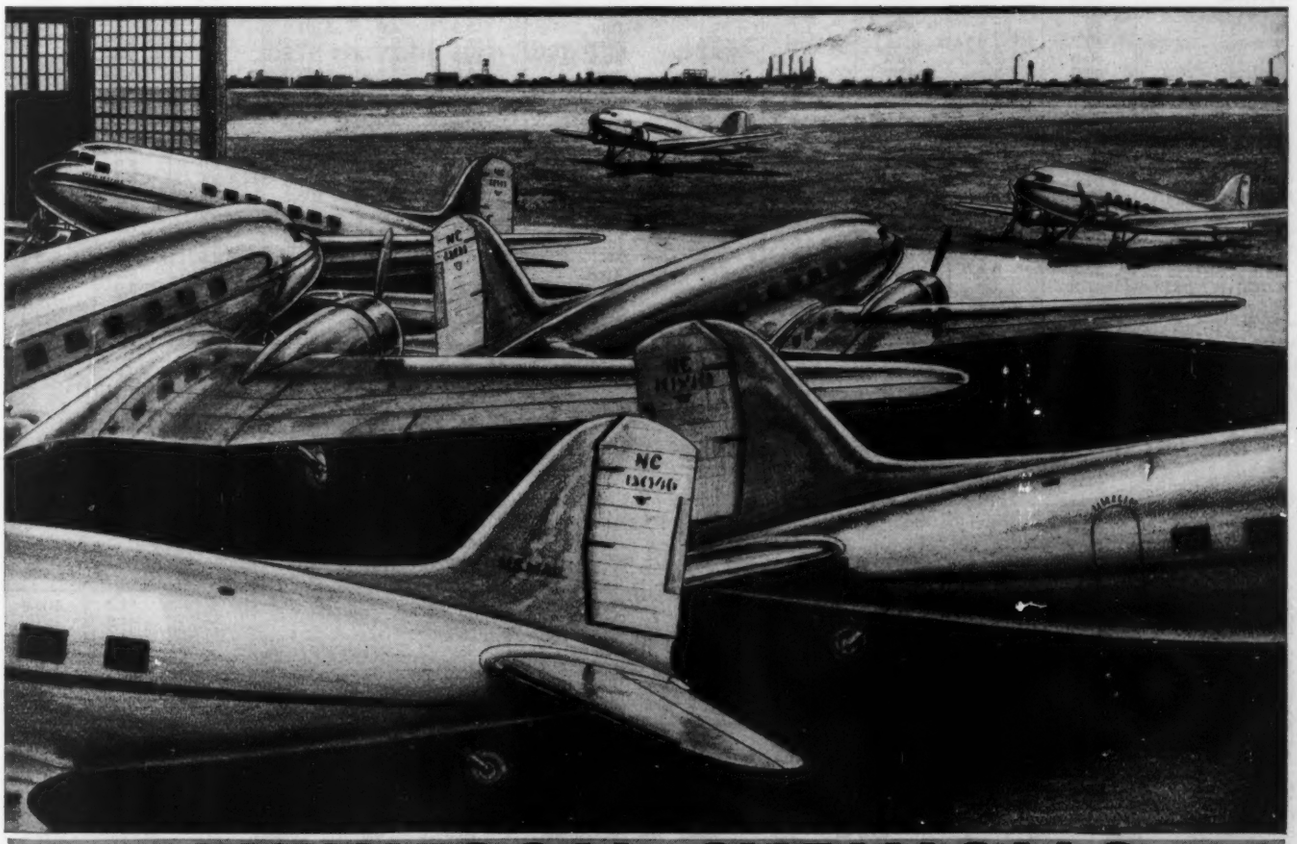
The Sky's The Limit

Suppose someone who lived forty or fifty years ago—say one of the founders of Mathieson—could pay us a visit today. And suppose we could have the pleasure of showing him the sights of 1941, of explaining the vast changes that have taken place since the turn of the century. What do you think would amaze the old gentleman most? If he were one of the pioneers who founded Mathieson, we believe he would be most interested in the revolutionary changes wrought by chemical progress and in the part his successors have played in building the present-day America. We would go about telling him the story as we tell it in this series of advertisements.

● Those, Mr. M., are airplanes. They were only a dream in your day. Now they're an accepted means of travel and transportation. Today you can journey from New York to San Francisco in only 10 hours. And speedier, more powerful ships are constantly being built.

In the development of this amazing industry, Mathieson Chemicals have contributed in many ways. The all-important dies used in making tools for plane and engine manufacture are conditioned with soap and grease containing alkalies. Dense soda ash is an essential raw material in the glass through which moderns look on a new world. Most important is the contribution caustic soda makes to the refining of high test gasoline for airplane engines. And in many another way — in upholstery, plastics, lacquers, rubber tires, lubrication oils and greases, even in those powerful landing lights, Mathieson products participate.

Yet the aviation industry is still young and Mathieson Chemicals have an active role to play in its growth and future success.



MATHIESON CHEMICALS

SODA ASH . . . CAUSTIC SODA . . . BICARBONATE OF SODA . . . LIQUID CHLORINE . . . BLEACHING POWDER . . . HTH PRODUCTS . . . AMMONIA, ANHYDROUS and AQUA . . . FUSED ALKALI PRODUCTS . . . SYNTHETIC SALT CAKE . . . DRY ICE . . . CARBONIC GAS . . . ANALYTICAL SODIUM CHLORITE

THE MATHIESON ALKALI WORKS (INC.)
60 E. 42ND STREET, NEW YORK, N. Y.

which prevailed in the early months of last year, is an important factor in the Atlantic Coast price structure. The comparison in California is likely to be somewhat less favorable, although some improvement from current levels may take place.

Fuel oil prices generally promise to remain at favorable levels throughout the year, although the experience may vary somewhat in different sections of the country. A gradual uptrend in lubricant prices from current levels is also to be expected, as excessive inventories are gradually liquidated.

Thus, it appears that rising demand this year may be accompanied by a similar trend of prices for all major petroleum products. The probable total of 1941 earnings for the industry under such conditions is far less important than the possibility that 1941 may represent the beginning of an upswing in the industry's earnings cycle. The relative invulnerability to excess profits taxes inherent in the industry's large capital investment and the liberal depletion allowances for tax purposes is an important factor in this connection.

Political Uncertainties

This promising picture is marred by several political uncertainties, including the threat of bureaucratic federal control. Although proposed legislation along these lines has met with little favor in the past, the threat today is far more serious. Pressure for federal enforcement of conservation has increased materially as a result of the present national emergency and the demonstrated vital necessity for oil in mechanized warfare. Public ignorance and even misinformation as to the extent of oil reserves, the ability of the industry to meet defense needs, and the current employment of conservation measures are important in this respect.

The Cole Bill, providing for a petroleum conservation office empowered to enforce conservation

Oil's Statistical Position Creates Better Market Prospects

Gasoline Statistics

(In Millions of Barrels)

1940—	*Total Domestic Production	Supply of Other Than Ref. Motor Fuel	Domestic Demand	Exports	†Stocks
November	49.8	1.5	49.1	2.2	79.5
October	51.6	1.7	53.8	2.1	79.2
September	50.5	1.9	52.3	1.9	81.9
August	50.3	1.8	55.3	2.1	83.7
July	49.4	1.6	53.9	1.7	89.1
June	49.2	1.6	55.5	2.6	93.6
May	50.9	1.4	52.9	2.0	100.9
April	48.5	1.1	47.7	2.1	103.6
March	50.2	1.1	44.6	2.3	103.7
February	46.7	1.1	37.6	1.9	99.3
January	49.5	1.2	40.4	2.3	91.0
1939—					
December	52.0	0.9	43.7	3.1	82.9
November	52.3	1.0	47.3	2.6	76.8
October	54.3	1.2	49.7	3.4	73.3
September	50.4	1.9	49.3	4.2	71.0
August	51.5	1.0	53.8	4.2	72.3
July	50.6	1.1	50.5	3.6	77.8
June	49.3	1.1	49.8	4.5	80.3
May	49.6	1.0	49.5	4.4	84.2
April	47.4	0.6	44.0	3.7	87.5
March	47.3	1.2	42.5	4.8	87.1
February	42.9	0.6	34.6	2.9	85.5
January	48.2	1.0	37.8	3.6	79.5

* Production including natural gasoline blended.
† End of period.
Source: American Petroleum Institute.

Crude Oil Statistics

(In Millions of Barrels)

1940—	Domestic Production	Imports	Refinery Runs	Directly Consumed and Transferred	Exports	*Stocks
November	106.9	3.9	105.4	2.5	3.8	263.2
October	113.4	3.8	109.4	1.8	5.3	263.9
September	109.3	3.9	107.8	2.4	4.3	263.1
August	110.5	4.2	108.8	1.1	4.2	264.3
July	113.2	4.0	107.9	2.2	5.6	263.5
June	111.7	3.7	108.2	1.3	5.7	262.0
May	118.3	4.1	111.8	1.9	4.9	261.8
April	116.0	3.2	107.0	1.0	4.3	258.1
March	120.1	2.9	110.1	2.1	4.0	251.1
February	108.7	2.3	101.8	1.3	3.3	244.4
January	113.1	2.0	106.5	3.5	4.2	239.7
1939—						
December	114.8	2.3	105.8	1.8	4.7	238.9
November	111.9	3.1	104.9	1.6	5.3	234.0
October	114.2	3.1	111.0	3.1	6.9	230.9
September	108.2	3.1	105.5	2.7	6.9	234.6
August	80.9	2.9	107.6	2.3	6.0	238.5
July	110.9	2.9	106.9	2.4	7.3	270.6
June	104.6	3.7	104.7	2.5	5.8	273.3
May	110.5	3.9	105.8	0.5	8.6	278.1
April	105.5	2.9	99.3	0.7	6.2	278.6
March	106.8	1.6	98.9	1.6	5.0	276.4
February	93.5	1.6	87.8	1.4	4.8	273.4
January	102.5	1.9	99.6	1.5	4.5	272.3

* End of period.
Source: American Petroleum Institute.

Gas, Oil and Distillate Fuel Oil Statistics

(In Millions of Barrels)

1940—	Domestic Production	Transfers from Crude Oil	Imports	Domestic Demand	Exports	*Stocks
November	15.1	0.5	0.5	17.1	1.3	46.6
October	14.4	0.5	0.3	13.6	1.4	49.0
September	14.7	0.5	0.3	10.7	0.9	48.8
August	15.0	0.6	0.3	8.7	1.5	45.0
July	14.4	0.5	0.2	7.5	1.8	39.4
June	14.2	0.5	0.2	7.3	2.1	33.6
May	14.5	0.6	0.2	10.1	2.1	28.2
April	15.3	0.6	0.3	12.2	2.0	25.1
March	16.3	0.6	0.4	16.5	2.3	23.1
February	16.3	0.5	0.5	17.9	1.2	24.6
January	16.5	0.5	.....	22.8	1.5	26.5
1939—						
December	14.4	0.6	.....	17.2	2.0	33.7
November	13.8	0.6	.....	14.4	2.1	37.9
October	15.0	0.6	.....	10.9	2.8	40.1
September	13.0	0.6	.....	10.0	3.0	38.1
August	13.2	0.6	.....	3.2	3.4	37.6
July	12.7	0.6	.....	6.9	2.9	35.3
June	13.5	0.6	.....	7.2	2.8	31.9
May	12.4	0.5	.....	7.5	4.0	27.8
April	13.3	0.5	.....	10.9	2.3	26.5
March	13.5	0.5	.....	13.9	2.9	25.9
February	12.7	0.5	0.1	14.8	2.1	28.7
January	14.1	0.5	.....	17.0	1.7	32.3

* End of period.
Source: American Petroleum Institute.

Residual Fuel Oil Statistics

(In Millions of Barrels)

1940—	Domestic Production	Transfers from Crude Oil	Imports	Domestic Demand	Exports	*Stocks
November	26.1	0.2	2.4	29.9	1.3	106.6
October	27.9	0.2	2.9	30.2	1.4	107.0
September	25.5	0.4	1.7	25.8	1.6	107.5
August	26.5	0.3	2.4	26.3	1.8	107.2
July	25.2	0.3	1.4	23.8	1.4	106.2
June	25.5	0.4	2.1	24.7	2.0	104.5
May	26.5	0.4	1.3	26.3	1.4	103.1
April	25.4	0.3	1.9	26.5	1.5	102.4
March	26.9	0.4	4.1	30.8	0.9	102.8
February	24.7	0.4	3.0	26.8	0.8	103.2
January	28.1	0.3	1.9	32.1	1.1	102.7
1939—						
December	26.9	0.6	0.8	31.8	1.3	105.6
November	26.1	0.2	1.0	29.9	1.1	110.4
October	27.6	0.4	1.5	28.3	1.3	114.0
September	26.3	0.3	0.7	27.1	1.6	114.1
August	25.3	0.2	1.7	25.5	1.6	115.6
July	25.6	0.2	1.5	23.3	1.1	115.5
June	24.8	0.5	1.9	24.2	1.7	112.6
May	27.0	0.4	2.1	25.8	1.9	111.2
April	24.8	0.9	1.3	25.1	1.5	109.3
March	25.0	0.9	1.3	29.0	2.0	108.9
February	21.6	0.5	1.0	25.6	0.9	112.6
January	25.8	0.8	1.0	28.6	1.4	116.1

* End of period.
Source: American Petroleum Institute.

When re-tubing your condenser or heat exchanger...

Look first to Anaconda

You'll find a complete range of tube alloys and a staff of experienced technicians whose consultation entails no obligation . . .

There is such a complication of operating factors having an influence on the service life of condenser tubes that no one tube alloy can possibly solve all problems.

To determine the tube alloy that will give the greatest service per dollar of cost requires metallurgical experience and practical knowledge of specific operating conditions. So we suggest that you take advantage of the experience of our Technical and Engineering Departments. They can place before you performance records of copper alloys under operating conditions similar to your problem. No charge is made for such consultation.

☆ ☆

ANACONDA TUBE SHEETS—We produce a complete line of plates and circles for marine and stationary condensers, heat exchangers, feed water heaters and oil coolers. The same careful technical supervision used to control the manufacture of Anaconda Condenser Tubes is given this material during the entire process of production. 4111-B

Here is one of the most complete books on the subject of tube alloys for condenser and heat exchangers in oil refinery operations and steam plants. In its 60 pages you will find real down-to-earth information which you can put to practical use. A free copy is yours for the asking.

ANACONDA

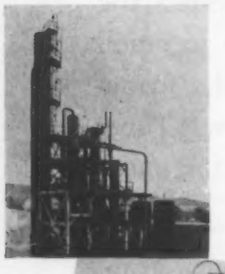
Anaconda Condenser Tubes

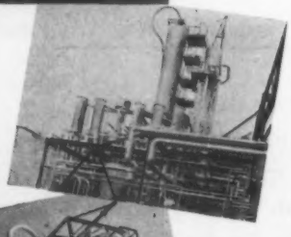
THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

Keep Your Temperatures Under Closer Control

Here's One Insulating Block that Covers the Full Range of Temperatures up to 1600° F.





BALDWIN-HILL MONO-BLOCK has proved its efficiency in many refinery installations by eliminating lag in bringing temperature to operating degree and by maintaining close control and more uniform temperature of processing equipment. Felted and bonded together by a patented process, its chemically stable black rockwool fibres are uniformly distributed to reduce heat flow to the minimum. MONO-BLOCK is available in lengths from 18" to 36"; widths from 6" to 18"; thicknesses from 1" to 4".

Other Baldwin-Hill Heat Insulation Products include: B-H Black Rockwool Blanket . . . B-H No. 1 Insulating Cement . . . B-H Weatherseal . . . B-H Bond-Tite . . . B-H No. 100 Pipe Covering . . . Miscellaneous Diatomaceous Earth and Asbestos Products effective up to 2000° F. Send for Catalog showing Complete Line, Heat Loss Charts, Insulating Efficiencies, and other data.

BALDWIN-HILL CO. 567 KLAGG AVE. TRENTON, N. J.

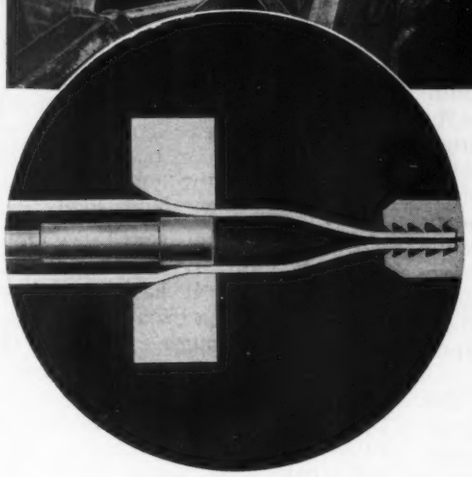
Branch Offices: NEW YORK BOSTON CHICAGO KALAMAZOO, MICH.

standards, appears reasonable on the surface, but its far reaching significance to the oil industry is to be found in the fact that determination of what is waste would be transferred from the individual states to a bureau of the federal government, vested with broad discretionary, legislative, judicial, and executive powers. Since the control over production involves control over prices, it is not inconceivable that the whole system of oil regulation might be thrown into the sphere of national politics. Moreover, oil interests fear that such legislation would be but the entering wedge for eventual complete government domination of the oil industry.

Probably not wholly unrelated to Administration efforts to secure this control legislation are the extensive anti-trust suits recently filed against 22 major oil companies, the American Petroleum Institute, and Ethyl Gasoline Corporation, and the "divorcement" bills pending in Congress. The anti-trust suit attacks the entire fundamental physical and economic setup of the industry, while the "divorcement" bills seek to divest integrated companies of their pipe lines, tankers, and marketing facilities.

Still another uncertainty recently injected into the picture is the decision of the Interstate Commerce Commission requiring pipeline companies to show cause by February 23, 1941, why their rates for crude oil transportation should not be reduced to a basis of an 8 percent return on their investment and minimum tenders on individual shipments reduced to 10,000 barrels. Although the bulk of the oil transported in pipe lines is for the account of the pipe-line company or its affiliates, such a reduction in rates, amounting to over 24 percent on the average, would involve the loss of considerable revenues in some cases.

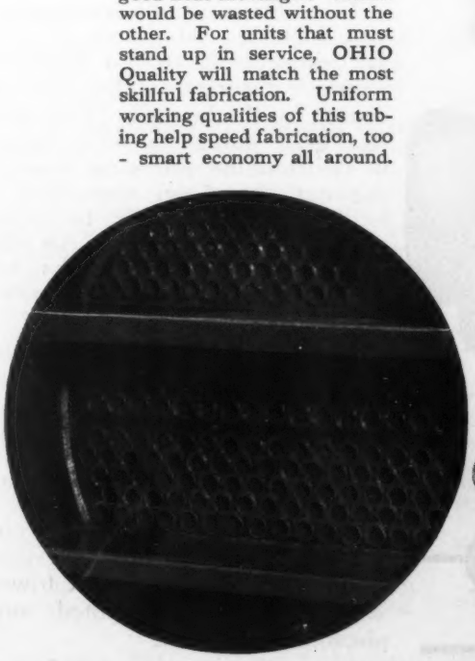
More important, perhaps, is the possible influence which this development might exert on the competitive situation within the industry. A number of small refiners using the pipe lines of the majors might suddenly have their delivered cost of crude oil considerably lowered to the benefit of their competitive positions, while, over the longer term, many new independent refineries may spring up in the heart of consuming centers remote from sources of crude oil.



Cold drawing, as shown above and in diagramatic view, gives control of size and surface both inside and outside.

●

It takes good tubing, plus careful craftsmanship, to make a good heat exchanger. Either would be wasted without the other. For units that must stand up in service, OHIO Quality will match the most skillful fabrication. Uniform working qualities of this tubing help speed fabrication, too - smart economy all around.



OHIO QUALITY *allows* NO COMPROMISE

Fifty years have elapsed since the first seamless cold drawn tubing manufactured in this country was produced at SHELBY, OHIO.

Since that time, the art of cold drawing seamless steel tubing at the same site in SHELBY, OHIO has been passed on from generation to generation with constant improvement in practice. And with it, continuous years of association with those manufacturers who are primarily concerned with a uniformly good product.

This present generation of OHIO craftsmen who carefully watch the drawing of each tube know that OHIO'S standard of quality demands the best in surface finish and exacting tolerances. They are quick to detect and correct any imperfections in the drawing process, which has always been considered one of the important steps in seamless tubing manufacture at SHELBY, OHIO.

Clean Non-oxidized finish - accuracy of size - uniformity of anneal, for good machinability and ductility - certified steels and physical properties are yours when you specify OHIO Quality Tubing.

"OHIO" QUALITY

32 Years Continuous Production Under this Trade Name

Destruction of Cooling Towers

A. R. MOBERG, President
Moberg Laboratories

A CONDITION of cooling towers that has probably existed for some time but has only recently forced itself upon the attention of the petroleum industry and others, is the comparatively rapid disintegration of the lumber in certain isolated cases. This particular condition evidences itself by the reduction of solid redwood to a pulpy, fibrous mass that renders the tower unfit for further service. The phenomena seems to involve a leaching out of the lignin or cellular structures binding together the long fibres, and might aptly be called "deligninification" of the lumber. The condition generally starts at the edges of the louvres and/or slats and gradually works deeper into the lumber and spreads over a wider area. The condition may be more pronounced on the outside of the louvre where spray or drippings only occasionally wet the lumber. Under such conditions a crystalline deposit may be found coating the affected area. This crystalline deposit is, of course, minerals that existed in the water and which have reached super-saturation due to concentration at the intermittently wet areas.

When this spongy condition has spread far enough the nails and hardware loosen in their anchorage and the tower is in danger of collapse. On account of the fibrous condition of the wood it is frequently impossible to brace the tower since no solid anchorage can be obtained for either nails or bolts.

In a few observed cases the presumed life of the tower has been shortened as much as 50 or 75 percent on account of this condition. When we realize that the average cooling tower represents a considerable investment and when we further realize that replacement of such a tower frequently means shutting down an entire plant while coils, pipes and so forth are removed and the new tower is built and put into position it must be evident that this condition represents a serious economic loss.

It is not to be supposed that this condition exists in the average cooling tower nor even in a great number of them but the fact that it does exist at all indicates that there must be a cause for the phenomena that should be isolated so that it can be corrected. The case is somewhat more alarming since the phenomena seems to have occurred more frequently in recent years.

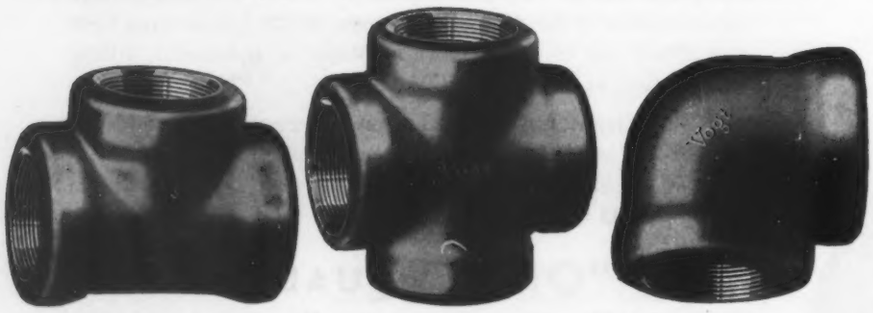
Since this condition has existed in widely separated sections of the country and under various climatic conditions it can scarcely be called a local condition. The first reaction was that the difficulty was caused by some condition in the water used. The pH of the water was thought to be a vital factor until it was discovered that two towers operating with the same pH in the water showed destructive action of the lumber in one case and not in the other. It seems certain, however, that some condition or series of conditions in the water must form the underlying cause of this phenomena. Whether it is basically a question of pH or whether it is a question of certain dissolved salts or whether algae conditions will have a bearing on it are questions which cannot at present be answered.

The author feels that there would be no wisdom in jumping to rash conclusions so it has been determined to make a broad enough and thoroughly enough survey of this situation so that comprehensive data can be assembled and a conclusion arrived at supported by such a mass of evidence as shall leave little question as to the fundamental cause and correction of this phenomena. To accomplish this it is the intention to assemble and study case histories of approximately 1000 cooling towers scattered throughout the country. These case histories will be supported by analyses of the waters and wood structures under every conceivable condition.

In addition to the assembly of case histories, laboratory research is being conducted to verify or disprove theories as they are presented by the histories. This work has been going on for a period of two months and some interesting data has been assembled. It is, however, too early to hazard any ultimate conclusions. An additional four to six months will probably be required to complete the work.

This survey is being conducted jointly by Fluor Corporation and Moberg Laboratories, both of Los Angeles, California. Complete data will be made public as soon as the investigators feel certain that their ultimate conclusions are correct. In the meantime, they will welcome any data, comments or suggestions from users of cooling towers whether they have noted such phenomena or not.

FORGED STEEL FITTINGS



CROSSES ELLS TEES UNIONS BUSHINGS PLUGS COUPLINGS

Sizes: 1/8" to 6"

Pressures (cold working) 3000 and 6000 lbs.

Quick Delivery from Large Houston Stocks!

MECO

MAINTENANCE ENGINEERING CORPORATION
P. O. Box 2637 Houston, Texas, U.S.A. Phone P-3135

Committees Named for A.P.I. Refining Division

Two committees of the Refining Division of the American Petroleum Institute have been appointed by J. Howard Pew, Sun Oil Company, institute vice president for the division. G. G. Oberfell, Phillips Petroleum Company, Bartlesville, heads the program committee and T. G. Delbridge, Atlantic Refining Company, Philadelphia, is chairman of the central committee on refining technology.

Members of the program committee are: H. W. Camp, Cities Service Oil Company, Bartlesville; F. S. Clulow, Shell Oil Company, San Francisco; R. A. Halloran, Standard Oil Company of California, San Francisco; J. Bemmett Hill, Sun Oil Company, Philadelphia; E. W. Isom, Sinclair Refining Company, New York; N. E. Loomis, Standard Oil Development Company, New York; K. G. Mackenzie, The Texas Company, New York; Walter Miller, Continental Oil Company, Ponca City; J. H. Rather, Socony-Vacuum Oil Company, New York; J. E. Roberts, Standard Oil Company (Indiana), Chicago; Herschel G. Smith, Gulf Oil Corporation, Philadelphia, and C. R. Wagner, The Pure Oil Company, Chicago.

Personnel of the committee on refinery technology is: Bruce K. Brown, Standard Oil Company (Indiana), Chicago; L. L. Davis, Continental Oil Company, Ponca City; B. C. Frichot, Deep Rock Oil Corporation, Cushing, Oklahoma; E. B. McConnell, Standard Oil Company (Ohio), Cleveland; J. T. McCoy, Tide Water Associated Oil Company, Bayonne; F. W. McCurry, Derby Oil Company, Wichita; A. E. Pew, Jr., Sun Oil Company, Philadelphia; R. H. Price, Pan-American Petroleum & Transport Company, Texas City; W. F. Sims, Panhandle Refining Company, Wichita Falls; H. D. Wilde, Humble Oil & Refining Company, Houston; M. P. Youker, Phillips Petroleum Company, Bartlesville, and Messrs. Camp, Clulow, Gard, Halloran, Isom, Loomis, Mackenzie, Rather, Smith and Wagner of the program committee.

New Process for Sweating Waxes is Announced

Engineers of Socony-Vacuum Oil Company and B F. Sturtevant Company have developed a new process for sweating waxes

The process consists essentially of an apparatus arrangement and control system by means of which the hot melted crude wax mixture is run into pans in a closed room. The room, together with the pans of wax, are air conditioned by means of the evaporative cooling method of water and air. The wax mass is cooled under close control, each individual constituent freezing separately as cooling proceeds, until pans contain total solids. Then all non-wax-like oils that might be present drain off, leaving the wax mixture in solid form.

Controlled heating then is employed, with temperature rising slowly and pausing at the right point as each fraction fuses and resulting liquid fraction is drawn off. This continues until all waxes up to the highest melting point are gone from the pans.

Apparatus consists of an evaporative cooler, steam heating unit, circulating fan, distributing ducts in the room, and pipe coils with water pump in the pans. The air is circulated rapidly in the room, cooled or heated as the case may be, and the water maintained approximately at air temperatures.

The Look Box

Recycling for W.P.R.A. Meeting

The technical meeting of the Ark-La-Tex Division of Western Petroleum Refiners Association will be held at Kilgore, Texas, February 14. The speaker will by Emby Kaye, vice president of Distillate Engineering and Processes Company, Tulsa, whose subject will be "Recycling and the Refiner."

This will be the first time the group has had opportunity to hear a discussion on the subject of recycling.

Chemical Engineers To Meet in Chicago

The thirty-third semi-annual meeting of the American Society of Chemical Engineers will be held in Chicago, May 19-21. Headquarters will be in the Edgewater Beach Hotel.

CONVENTIONS

FEB.	
24–25	Liquefied Petroleum Gas Association, Annual Convention, Chicago.
MAR.	
3– 7	American Society for Testing Materials, Hotel Mayflower, Washington.
17–22	Oil Burner Institute's National Oil Burner Progress Exhibition, Commercial Museum, Philadelphia.
APR.	
7–11	American Chemical Society, St. Louis.
9–10	Midwest Power Conference, Palmer House, Chicago.
16–18	Western Petroleum Refiners Association, Arlington Hotel, Hot Springs.
23–25	Natural Gasoline Association of America, Annual Convention, Baker Hotel, Dallas.
23–25	Petroleum Industry Electrical Association, Mayo Hotel, Tulsa.
24–25	National Petroleum Association, Cleveland Hotel, Cleveland.
MAY	
2– 3	Petroleum and Natural Gas Conference, State College, Pennsylvania.
5– 8	American Gas Association, Natural Gas Section, Dallas.
19–21	American Institute of Chemical Engineers, Semi-Annual Meeting, Edgewater Beach Hotel, Chicago.
JUNE	
16–20	Petroleum Division Meeting of the American Society of Mechanical Engineers, Kansas City.
23–27	American Society for Testing Materials, Annual Meeting, Palmer House, Chicago.

NGAA Convention Committees Named

Committees have been named for both program and arrangements for the twentieth annual meeting of the Natural Gasoline Association of America. The convention, April 23-25, will be held in Dallas, the first time the association has held its annual meeting outside of Tulsa, where headquarters are maintained.

T. R. Goebel, Shell Oil Company, Houston, is chairman of the committee which will prepare the technical program. Other members are: H. H. Beeson, Sabine Valley Gasoline Company, Shreveport; George E. Edgett, The Carter Oil Company, Tulsa; H. A. Ells, Cities Service Oil Company, Bartlesville; F. E. Fisher, Skelly Oil Company, Pawhuska, Oklahoma; R. D. Gibbs, Union Oil Company, Los Angeles, and Allen T. Givens, Coltexo Corporation, Monroe, Louisiana.

J. R. Jarvis, Lone Star Gasoline Company and vice president of the association, Dallas, is chairman of the local arrangements committee, whose other members are John B. Atkins, Parage Gasoline Company, Shreveport, and A. M. Brackett, Roeser & Pendleton, Fort Worth.

Automotive Survey Committee Named

The automotive survey committee of the Division of Refining of the American Petroleum Institute has been named by T. G. Delbridge, who is chairman of the central committee of refinery technology. Members are:

K. G. Mackenzie, The Texas Company, New York, chairman; H. T. Bennett, Mid-Continent Petroleum Corporation, Tulsa; H. W. Camp, Cities Service Oil Company, Bartlesville; A. J. Blackwood, Esso Laboratories, Elizabeth, New Jersey; David E. Day, Richfield Oil Corporation, Los Angeles; T. G. Delbridge, Atlantic Refining Company, Philadelphia; E. W. Gard, Union Oil Company, Los Angeles; E. A. Halloran, Standard Oil Company of California, San Francisco; L. E. Hebl, Shell Oil Company, Wood River; E. W. Isom, Sinclair Refining Company, New York; J. T. McCoy, Tide Water Associated Oil Company, Bayonne, New Jersey; Walter Miller, Continental Oil Company, Ponca City; G. G. Oberfell, Phillips Petroleum Company, Bartlesville; A. E. Pew, Jr., Sun Oil Company, Philadelphia; J. S. Piggott, Gulf Research & Development Company, Pittsburgh; J. B. Rather, Socony-Vacuum Oil Company, New York, and C. R. Wagner, Pure Oil Company, Chicago.

Pennsylvania Technicians Hear Research Progress Report

Members of the technical advisory committee of the Pennsylvania Grade Crude Oil Association met with other representatives of the oil and automotive industries at State College, Pennsylvania, last month to hear reports on research work being conducted in the petroleum refining laboratory at Pennsylvania State College. The association has maintained a program of research at the institution for more than ten years, and the technologists in the laboratory reviewed the progress in this work during the last decade, particularly recent studies on the oxidation of

Technical Advisory Committee of the Pennsylvania Grade Crude Oil Association.

motor oils. During the meeting, Frank J. Philippbar, Kendall Refining Company, Bradford, was elected chairman of the committee. An accompanying picture, taken during the meeting, shows:

Front row: J. E. Moorhead, executive secretary of the association; F. L. Carnahan, Pennsylvania State College; M. R. Fenske, director of research in the petroleum refining laboratory, State College; Parker L. Melvin, association president; H. C. Mougey, General Motors Corporation, Detroit; Dean Frank C. Whitmore, school of chemistry and physics, Pennsylvania State College; and L. A. Blanc, Caterpillar Tractor Company, Peoria, Illinois.

Second row: Paul W. Emery, United Refining Company, Warren; Wes W. Dunlap, Pennsylvania Grade Crude Oil Association; Joseph E. Keller, National Petroleum Association, Washington; Thomas G. Murphy, Franklin Creek Refining Corporation, Franklin, Pennsylvania; W. T. Sieber, Waverly Oil Works Company, Pittsburgh; George M. Kirkwood, Pennsylvania Refining Company, Karns City, Pennsylvania; C. M. Larson, Sinclair Refining Company, New York; R. E. Dunham, Sinclair Refining Company, New York; L. M. Baltzell, Wolf's Head Oil Refining Company, Oil City; W. A. Johnston, Bradford Penn Refining Corporation, Clarendon, Pennsylvania; Frederic R. Speed, Pennsylvania Grade Crude Oil Association, Detroit, and Philipp bar.

Back row: A. W. Lewis, Tide Water Associated Oil Company, Bayonne; S. F. Pratt, Pennsylvania Grade Crude Oil Association; Clifford Koch, Canfield Oil Company, Cleveland; MacLean Houston, United Refining Company, Warren; Ben L. Heath, Freedom Oil Company, Freedom, Pennsylvania; H. W. Hubbell, Valvoline Oil Company, Franklin; W. B. Smith, Wolf's Head Oil Refining Company, Oil City; Louis W. Hodous, Canfield Oil Company, Cleveland, and H. L. Hemmingway, Kendall Refining Company, Bradford.

Japanese Companies Seek New Sources for Oil Supply

Several Japanese companies, including Mitsui, Mitsubishi, and Ogura, have founded the Toa Oil Corporation, a new importing company, with capital of 5,000,000 yen, to promote importation of petroleum from non-American countries, in view of difficulties of importing oils from the United States. Iran and the Netherlands East Indies are under consideration as desirable sources, and it is recognized that the oil fields in the Netherlands part of Borneo offer especially favorable transport facilities.

Reports last fall indicated that Borneo Petroleum Company, a Japanese company, founded in 1929, presumably with participation of Netherlands capital, had obtained its first success in several years of prospecting by completing a producing well on the eastern coast of Netherlands Borneo, with initial production of 35 barrels daily.

Seek Simplification Of Lubricants

Simplification of motor-vehicle lubrication and improvement of lubrication service by reducing the number of types of lubricants required are being developed jointly by representatives of the petroleum and automotive industries.

The American Petroleum Institute's Committee on Lubrication, whose members have been consulting with automotive engineers, has prepared for both industries a tentative list of 22 types of lubricants which dealers and service stations featuring complete passenger-car lubrication should stock and use. The list as tentatively agreed upon contains four types of motor oil, four gear lubricants, nine general chassis lubricants, one lubricant for overdrive transmissions, and four optional lubricants for shock absorbers, hydraulic brakes, etc. It is believed that these lubricants will meet present requirements and that continued study of mutual problems will result in further simplification. Following is the complete list:

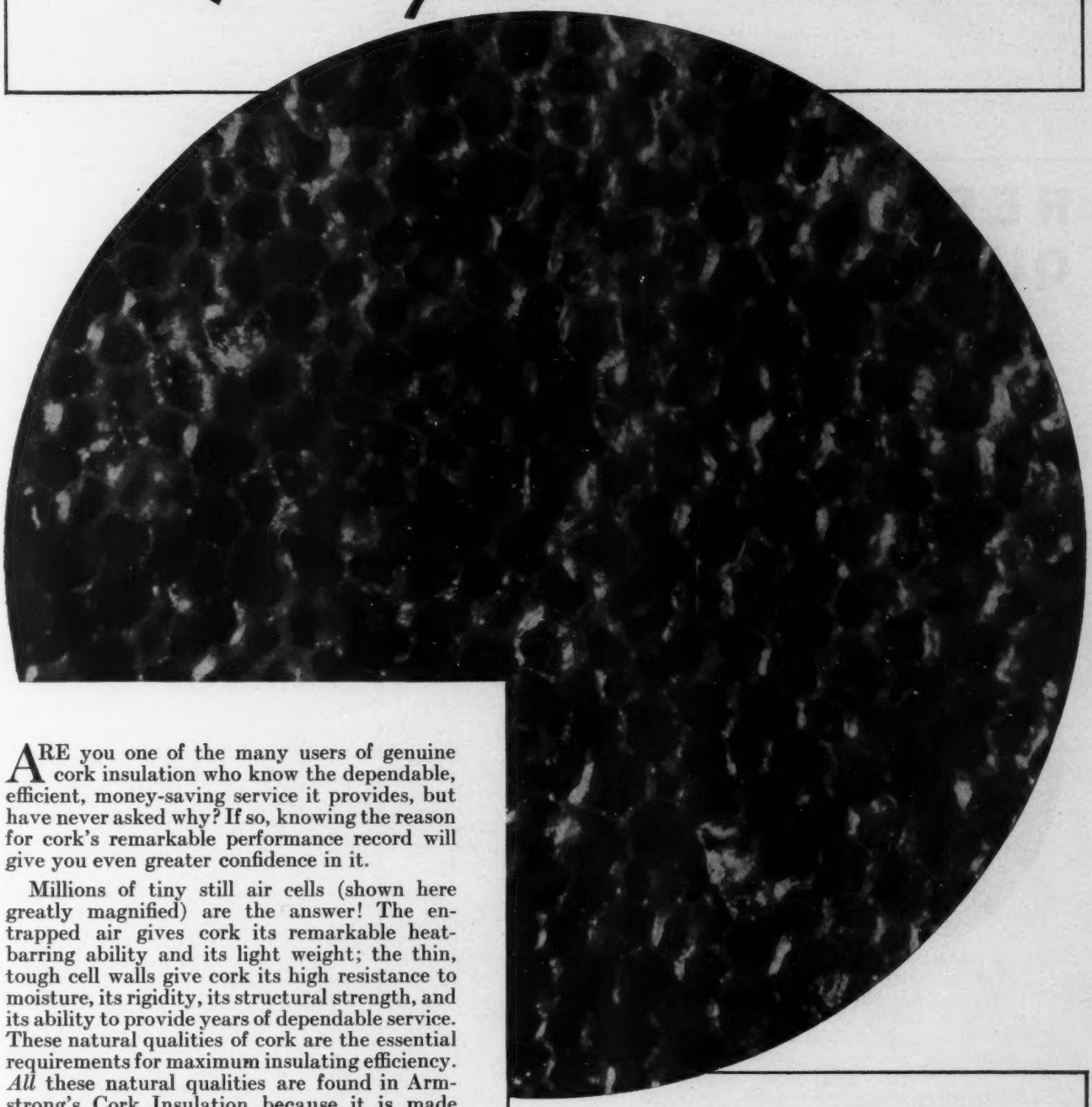
	Each Brand of Motor Oil		No. of Products Required	
	Summer	**Winter**		
I. Motor Oils For:				
(1) Crankcase and Misc. Oil Can Lubr.	SAE 10 or 10W SAE 20 or 20W SAE 30 SAE 40	10W 20W	4	**4**
II. Gear Lubricants For:				
(1) Conventional Transmissions (2) Rear Axles—all types (3) Steering Gear Boxes (Oil Type) (4) Oil Type Universal Joints (5) Overdrive Transmissions*	Universal Type Gear Lubricant SAE 80, 90 and 140		3	**3**
III. Chassis Lubricants For:				
(1) General Chassis Fittings and Covered Springs (2) Steering Gear Boxes—grease type (3) Wheel Bearings	Chassis Lubricant†		1	
(4) Universal Joints—grease type (5) Distributor Grease Cups (6) Clutch Release Bearings	Wheel Bearing Lubricant and No. 2 Cup Lubricant		2	
(7) Water Pumps (Grease Lubricated)	Waterproof Grease Lubricant		1	
(8) Rubber Bushings	Special Rubber Lubricant		1	
(9) Wet Clutch (Hudson)	Special Wet Clutch Compound or other suitable product		1	
(10) Special Spring Lubricant (Ford)	Special Asbestos-Talc Lubricant or other suitable product		1	
(11) Open Springs and Automotive Heat Control Valves	Pentrating Oil or Flushing Oil		1	
(12) Air Cleaners	SAE 50 Motor Oil		1	**9**
IV. Special Products:				
(1) Hydra-Matic Transmission (Cadillac and Oldsmobile) (2) Fluid Fly Wheel (Chrysler—De Soto—Dodge)	Special Oil—to be serviced at car dealer only			
(3) Vacamatic Underdrive Transmission (Chrysler 6) (4) Simplimatic Transmission (De Soto)	Special 20W Motor Oil plus 10% sulfur saponifiable oil		1	**1**
V. Optional Products:				
(1) Shock Absorbers—Piston Type (Delco and Monroe)	Special Light Bodied Shock Absorber Fluid		1	
(2) Shock Absorbers—Vane Type (Houdaille)	Special Heavy Shock Absorder Fluid		1	
(3) Hydraulic Brakes	Special Hydraulic Brake Fluid		1	
(4) Door Latches, Strikers and Hood Lacings	Special Grease Stick		1	**4**
TOTAL				**21**

*** Note:** Some car manufacturers recommend SAE 50 (winter) and SAE 70 or 60 (summer) motor oils for overdrive transmissions and that E P lubricants shall not be used. These products will be required temporarily.

† Note: Summer and winter grades now in general use. Summer grade temporarily desirable for older cars during summer season.

HERE'S THE INSIDE STORY OF

Money-saving CORK insulation!



ARE you one of the many users of genuine cork insulation who know the dependable, efficient, money-saving service it provides, but have never asked why? If so, knowing the reason for cork's remarkable performance record will give you even greater confidence in it.

Millions of tiny still air cells (shown here greatly magnified) are the answer! The entrapped air gives cork its remarkable heat-barring ability and its light weight; the thin, tough cell walls give cork its high resistance to moisture, its rigidity, its structural strength, and its ability to provide years of dependable service. These natural qualities of cork are the essential requirements for maximum insulating efficiency. *All* these natural qualities are found in Armstrong's Cork Insulation because it is made entirely of clean, pure, natural cork granules!

If you're not already using Armstrong's Cork Insulation (Corkboard for cold rooms, refrigerated equipment, walls, roofs and ducts, or Cork Covering for cold lines), it will pay you to find out about it now. For facts and engineering data, write today to Armstrong Cork Company, Building Materials Division, 1001 Concord Street, Lancaster, Pa.

Armstrong's

CORK INSULATION

CORKBOARD · CORK COVERING

Analysis of Illinois Oils

The United States Bureau of Mines has completed analysis of 35 samples of Illinois crude oils, Bulletin R. I. 3532. The work was done by Harold M. Smith, chemist of the Petroleum Experiment Station, Bartlesville. Some of the characteristics of the oils are given in this part of the report:

"The similarity of the oils is shown by comparison of the correlation indexes of similar fractions. These indexes are given on each analysis under the column headed 'C.I.,' which stands for the correlation index.

"A description of the development and use of this term is too long for insertion in this report but the following paragraph, taken from Technical Paper 610, gives its general significance:

"'The correlation index is a number whose magnitude indicates certain characteristics of a crude oil distillation fraction. If a fraction were composed exclusively of normal paraffin hydrocarbons, the value of the index number would be zero. If the fraction be from a paraffin-base crude oil of the usual type, the index will not be zero but will be small, while fractions from intermediate and naphthene base crude oils will be increasingly greater values for the indexes.'

"Index numbers, therefore, range from zero for the normal paraffins to approximately 75 for the very naphthenic distillates. The index system, which is based upon the average boiling point and specific gravity of the Hempel fractions, has been so arranged that benzene has an index of 100; and certain crude oils, such as those from Borneo, may have numbers exceeding 100, indicating the probable presence of polycyclic aromatic compounds.

"In the series of crude oils discussed in this report the indexes show only slight differences, except for four oils previously noted (Casey, Gillespie-Wyen, Griffin and Lawrence County) . . . "

Concerning sulphur content which is given in one table, the report is:

"It is of interest that most of the high-sulphur oils are found in that group of fields along the eastern Illinois border and further that no low-sulphur oils are found in that area. Thus, if the oils are divided into two groups, these having less than 0.18 percent sulphur and those with 0.18 sulphur or more, some of the present samples from the eastern area will fall into the first group (except for Mill Shoals in the extreme northwest corner of White County), all of the samples from the area farther west in Wayne, Richland and Clay counties will fall into the second group, and only six of the remaining samples from the south central area have over 0.18 percent sulphur. It will be of interest to note whether a more extended survey of Illinois oils will corroborate this apparent segregation of high-sulphur oils.

"As indicated by the correlation index, all these Illinois oils are similar to Mid-Continent crude oils of similar gravity and they are used by refiners to manufacture a similar series of products. This series includes straight-run gasoline, cracked gasoline (both thermal and catalytic), kerosene, fuel oils, lubricating oils, asphalt and coke. No unusual problems, with the possible exception of sulphur in the heavy naphtha distillates from Devonian production, are found."

Increase in Crude Stocks Analyzed

"Year-end figures on stocks of crude petroleum show that production in 1940 was substantially in excess of consumptive demand," H. B. Fell, executive vice-president of the Independent Petroleum Association of America, said in a statement in which the statistics on stocks were analyzed.

His analysis of stocks follows: "The increase or decrease in stocks of crude petroleum by grade or state or origin during the period of a year indicates whether or not there has been a market demand for the crude petroleum produced in each respective state or of the particular grade.

"If oil produced is manufactured into refined products it, of course, does not go into storage as crude oil. If stocks of crude oil produced in any state increase during any period that means that more oil was produced during that period than was manufactured into refined products whereas if stocks of crude oil produced in any state decrease during any period that means that more oil was manufactured into refined products during that period than was produced.

"Comparing the stocks of crude petroleum in the United States as of December 30, 1939, and as of December 28, 1940, we find an increase in stocks of refinable crude oil during that period

REPLACE GASKETS QUICKLY AND EASILY

with

FLANGE-JACKS!

TO OPERATE FLANGE-JACKS: Remove opposite flange bolts, insert jaws of Flange-Jacks in holes and tighten. After removing other bolts, tighten down jack-screws together, separating flanges evenly.

GASKETS on existing pipe lines can be quickly and easily renewed with Flange-Jacks—a specially designed tool recently introduced by Garlock.

No hammers . . . no chisels . . . no wedges . . . no broken flanges . . . no damaged faces . . . no pipe vibration . . . no dangerous sparks . . . no long shut-downs.

You just let Flange-Jacks do the work. Even if a joint is located where working space is cramped Flange-Jacks will open it easily. Write for descriptive folder!

THE GARLOCK PACKING COMPANY

PALMYRA, NEW YORK

Tulsa, Okla. Houston, Texas Los Angeles, Calif.

Sweetening Natural Gas

AND OTHER PETROLEUM PRODUCTS WITH CAUSTIC SODA OR OTHER ALKALIES

INVOLVES LARGE SURFACE CONTACT

ADVANTAGES OF *Raschig Rings*

1. Large surface exposure per unit of volume gives high reaction efficiency.
2. Large free cross section minimizes internal friction and gas velocity.
3. Large free volume allows time for complete absorption.

FURTHER ADVANTAGES OF *Carbon*

1. High resistance to the destructive action of corrosive materials, such as sulphides and hot alkaline solutions, assures long life.
2. High resistance to thermal shock reduces spalling and breakage.
3. Low weight per unit volume reduces cost of tower construction.

"NATIONAL" CARBON RASCHIG RINGS ARE MADE IN 9 STANDARD SIZES:

¼", ½", ¾", 1", 1¼", 1½", 2" and 3" smooth rings and 1" splined rings.

1" splined rings provide 25% more absorption surface than 1" smooth rings.

NATIONAL TRADE-MARK **CARBON *Raschig* RINGS**

ARE THE IDEAL TOWER PACKING FOR THIS PURPOSE

National Carbon Company, Inc.
Cleveland, Ohio

Gentlemen: Please send bulletin giving full information on "National" Carbon Raschig Rings.

NAME_____

FIRM_____

CITY_____ STATE_____

R

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

Carbon Sales Division, Cleveland, Ohio

GENERAL OFFICES

30 East 42nd Street, New York, N. Y.

BRANCH SALES OFFICES

New York, Pittsburgh, Chicago, St. Louis, San Francisco

of one year of 23,810,000 barrels, or an increase of slightly over 10 percent.

"The following table shows stocks of crude petroleum as of December 30, 1939, and as of December 28, 1940, by grade or state of origin, together with increases or decreases between those two dates and the percentage of increase or decrease:

Grade or origin	(In thousands of barrels) December 30 1939	December 28 1940	Increase or decrease	Percentage of increase or decrease
Pennsylvania Grade	4,688	4,250	— 438	— 9.55%
Other Appalachian	1,436	1,401	— 35	— 2.44%
Lima-Michigan	1,456	1,268	— 188	—12.91%
Illinois-Indiana	16,592	20,714	+ 4,119	+24.89%
Arkansas	2,683	3,603	+ 920	+34.29%
Kansas	6,814	8,542	+ 1,728	+25.36%
Louisiana	11,162	13,981	+ 2,819	+25.25%
New Mexico	5,939	7,591	+ 1,652	+27.82%
Oklahoma	60,377	63,220	+ 2,843	+ 4.71%
Texas	70,611	83,512	+12,901	+18.27%
Rocky Mountain	17,669	15,449	— 2,220	—12.57%
California	35,320	35,190	— 130	— 0.37%
Foreign	2,995	2,831	— 164	— 5.47%
Total United States refinable	237,742	261,552	+23,810	+10.02%
Heavy in California	13,292	11,904	— 1,388	—10.44%

"It will be noted from the above table that the stocks of refinable crude oil produced in California decreased slightly during the year and that the stocks of heavy crude in California decreased over 10 percent. This means that the stocks of refinable crude oil east of California increased over 10 percent during the year and you will note from the table that the stocks of crude oil by state of origin increased for Illinois-Indiana, Arkansas, Kansas, Louisiana, New Mexico, Oklahoma, and Texas. There were increases in stocks of oil produced in all of the oil producing states that are members of the Interstate Oil Compact, except Colorado, and there was a substantial increase in the stocks of oil produced in practically all of these states.

"In addition to the increase in stocks of crude oil during the past year, figures now available indicate that for the area East of California that on January 4, gasoline stocks were 3,771,000 barrels greater, gas oil stocks 9,581,000 barrels greater, and residual fuel oil stocks 6,359,000 barrels greater than at the same time last year.

"These figures show that production during the year 1940 was very substantially in excess of consumptive demand and that the excess production came from the Compact states and the states of Illinois, Arkansas, and Louisiana.

"In order to properly conserve our natural petroleum resources the regulatory bodies of the various oil producing states and the Interstate Oil Compact should carefully analyze the statistical developments pertaining to stocks of crude petroleum and the refined products thereof during the year 1940 and take such steps as may be advisable to eliminate excess stocks and the waste that result therefrom."

From left to right, C. H. Wagner, E. R. Turner, Dr. Robert E. Wilson and C. F. Hatmaker, officials of Pan American Petroleum & Transport Company and American Oil Company, pictured on arrival at Houston while on an inspection tour.

Conference Dates Set

The annual petroleum and natural gas conference conducted by Pennsylvania State College, State College, Pennsylvania, will be held May 2 and 3. It is sponsored by three groups within the Pennsylvania oil industry, the Pennsylvania Grade Crude Oil Association, Bradford District Oil Producers Association and Pennsylvania Natural Gas Men's Association.

Dr. S. J. Pirson of the School of Mineral Industries is arranging the program.

E. L. Dennis Joins L. S. U. Faculty

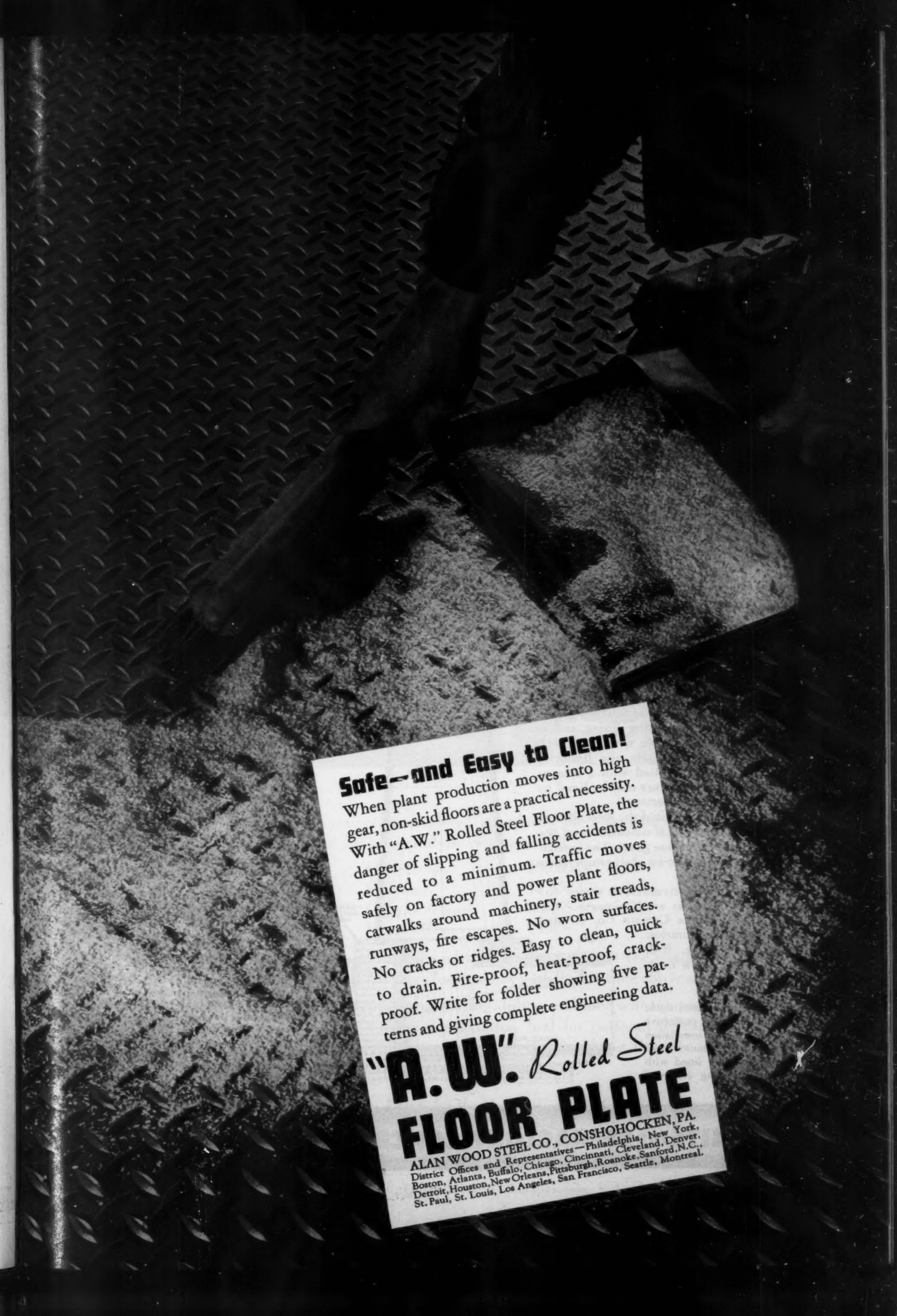
Edwin L. Dennis, chief combustion engineer of Coppus Engineering Corporation, Worchester, Massachusetts, has joined the faculty of Louisiana State University, Baton Rouge. He assumed his duties there February 1 but will continue to serve with the Coppus organization.

He is a graduate of the school, receiving his degree in science in 1924. His first work was with The Texas Company. From 1926 to 1938 he served in various capacities with Godchaux Sugar, Inc., being chief of its engineering department in New Orleans when he went with the Coppus Engineering Corporation.

Pan American Officials Make Inspection Trip

Dr. Robert E. Wilson, president of Pan American Petroleum & Transport Company and petroleum advisor to the National Defense Council, headed a group of 30 sales and division managers, chemists and technicians of American Oil Company, marketing subsidiary of Pan American Petroleum & Transport Company, on an inspection trip of Gulf Coast production and pipe line operations and the company's refinery at Texas City. Other executives with the party were C. H. Wagner, general manager, and C. F. Hatmaker, vice president, both of American Oil Company, who were joined at Houston by E. R. Turner, vice president and general manager of Pan American Production Company, and D. J. Smith, vice president in charge of refining.

Dr. Wilson remarked that there was still much work to be done on the defense program, and reviewed recommendations for building up stocks of 100-octane gasoline, augmentation of transportation facilities to the East Coast, where any difficulties would hamper civilian deliveries, underground storage of Army and Navy gasoline stocks, additional facilities for manufacture of 100-octane gasoline, and plans for increased manufacture of toluene from petroleum products.


Safe—and Easy to Clean!
When plant production moves into high gear, non-skid floors are a practical necessity. With "A.W." Rolled Steel Floor Plate, the danger of slipping and falling accidents is reduced to a minimum. Traffic moves safely on factory and power plant floors, catwalks around machinery, stair treads, runways, fire escapes. No worn surfaces. No cracks or ridges. Easy to clean, quick to drain. Fire-proof, heat-proof, crack-proof. Write for folder showing five patterns and giving complete engineering data.
"A.W." Rolled Steel
FLOOR PLATE
ALAN WOOD STEEL CO., CONSHOHOCKEN, PA.
District Offices and Representatives—Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, Pittsburgh, Roanoke, Sanford, N.C., St. Paul, St. Louis, Los Angeles, San Francisco, Seattle, Montreal.

Bureau Forecasts Slight February Demand Increase

Daily average demand for crude will be 3,628,900 barrels for February, an increase of 37,900 barrels over the estimate for January and one percent above the actual demand for February, 1940, it was forecast by the United States Bureau of Mines.

Currently, the bureau declared, actual experience is running close to forecasts. The daily average crude production during the five weeks from December 7 to January 11 was 3,463,000 barrels, and runs to stills 3,566,000 barrels, while during the period domestic crude stocks declined an average of 77,000 barrels a day, indicating a demand of 3,540,000 barrels. The forecast for December was for 3,560,000 barrels.

At the same time, the bureau said, domestic demand for motor fuel during the final quarter of last year increased about six percent over the same period in 1939, and was substantially as forecast, but exports of motor fuel were at a higher rate than was anticipated.

"While the domestic demand for distillate fuel oils has been a little above expectations," it was stated in a review of the general situation, "stocks on December 31, 1940, were about 9,000,000 barrels greater in the districts east of California than at the end of 1939. This increase in distillate fuel oil stocks coincides with a decline of about 8,000,000 barrels in exports during the last six months of 1940, compared to the same period in 1939, and to an increase of 2,000,000 barrels in imports during the same period.

"The domestic demand for residual fuel oils is becoming more active. Estimated stocks in the districts east of California were about 3,500,000 barrels greater on December 31, 1940, than at the end of 1939. This increase was closely related to the fact that stock reductions in the last quarter of 1940 were about 3,000,000 barrels less than in the same period in 1939, while imports increased by approximately the same amount."

It was emphasized in this connection that the bureau's forecasts for export and imports are "short-term projections of actual current trends and do not involve any recommendations as to long-term policies."

Domestic demand for motor fuel in February is estimated at 39,000,000 barrels, the daily average of which, it was said, is about 7.6 percent higher than the actual demand in February a year ago.

The estimate for exports of motor fuel, based upon forecasts by the principal exporters, is 1,800,000 barrels, 100,000 barrels less than actually shipped in February, 1940.

Stocks of finished and unfinished gasoline increased 332,000 barrels during November to 79,517,000 barrels at the end of that month, and statistics of the American Petroleum Institute indicate they increased about 3,900,000 barrels during December, indicating an inventory of approximately 83,400,000 barrels at the end of the year compared with 82,865,000 barrels at the end of 1939, it was explained. The bureau is estimating an increase of 5,800,000 barrels in finished stocks in February, which is 2,000,000 barrels less than the increase in that month last year, when the heavy demand for heating oil entailed large runs to stills.

Benzol production and direct sales of natural gasoline are estimated at 1,300,000 barrels, making an indicated refinery production of 45,300,000 barrels, which the bureau distributed among the several districts, as follows: East Coast, 5,930,000 barrels; Appalachian, 1,680,000 barrels; Indiana-Illinois, 9,830,000 barrels; Oklahoma, 2,380,000 barrels; Kansas-Missouri, 2,510,000 barrels; Texas Inland, 3,000,000 barrels; Texas Gulf Coast, 10,730,000 barrels; Louisiana Gulf Coast, 1,230,000 barrels; Inland Louisiana-Arkansas, 790,000 barrels; Rocky Mountain, 1,210,000 barrels, and California, 6,010,000 barrels.

On the basis of an anticipated blend-

Bureau of Mines Forecast of Crude Oil Demand for February

State	Forecast February, 1941	Forecast January, 1941
Texas	1,312,900	1,297,500
California	595,700	594,800
Oklahoma	442,500	439,000
Illinois	342,100	340,300
Louisiana	288,600	287,400
Kansas	193,200	191,000
New Mexico	100,700	100,000
Wyoming	74,600	73,900
Arkansas	66,100	66,100
Pennsylvania	50,000	48,000
Michigan	47,500	46,100
Indiana	22,500	20,000
Montana	20,000	19,000
Mississippi	16,100	15,200
Kentucky	15,400	14,800
New York	12,900	13,000
West Virginia	10,900	10,000
Ohio	10,100	9,000
Colorado	3,900	3,900
Nebraska	3,200	2,000
	3,628,900	3,591,000

STEEL STACKS LINED QUICKLY ...AT LOW COST!

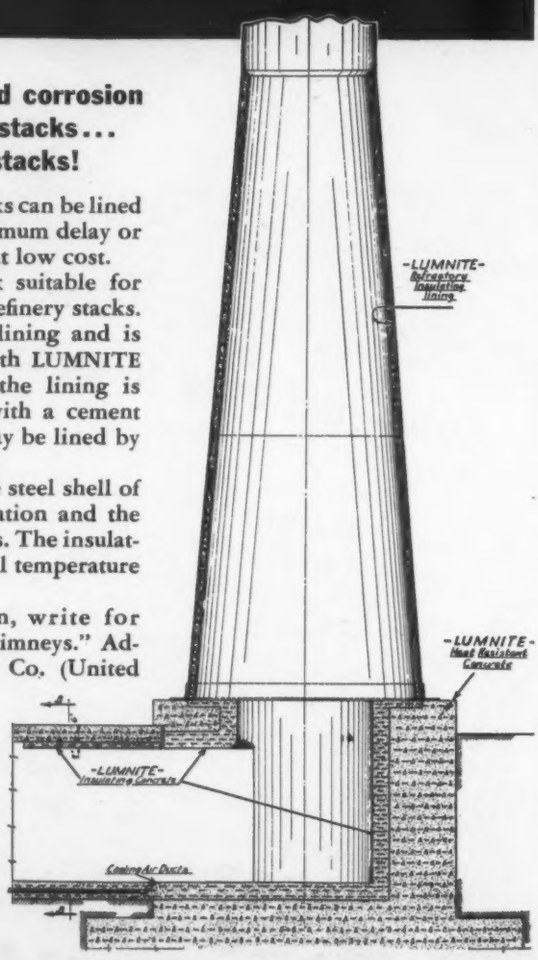
Protection from heat and corrosion means new life for old stacks... longer life for new stacks!

YOUR new or old steel stacks can be lined with LUMNITE with minimum delay or interruption to service—and at low cost.

Here is a lining 2½" thick suitable for highest temperatures met in refinery stacks. It is a refractory insulating lining and is corrosion resistant. Made with LUMNITE and a refractory aggregate, the lining is easily and quickly applied with a cement gun. Small stacks and flues may be lined by hand before or after erection.

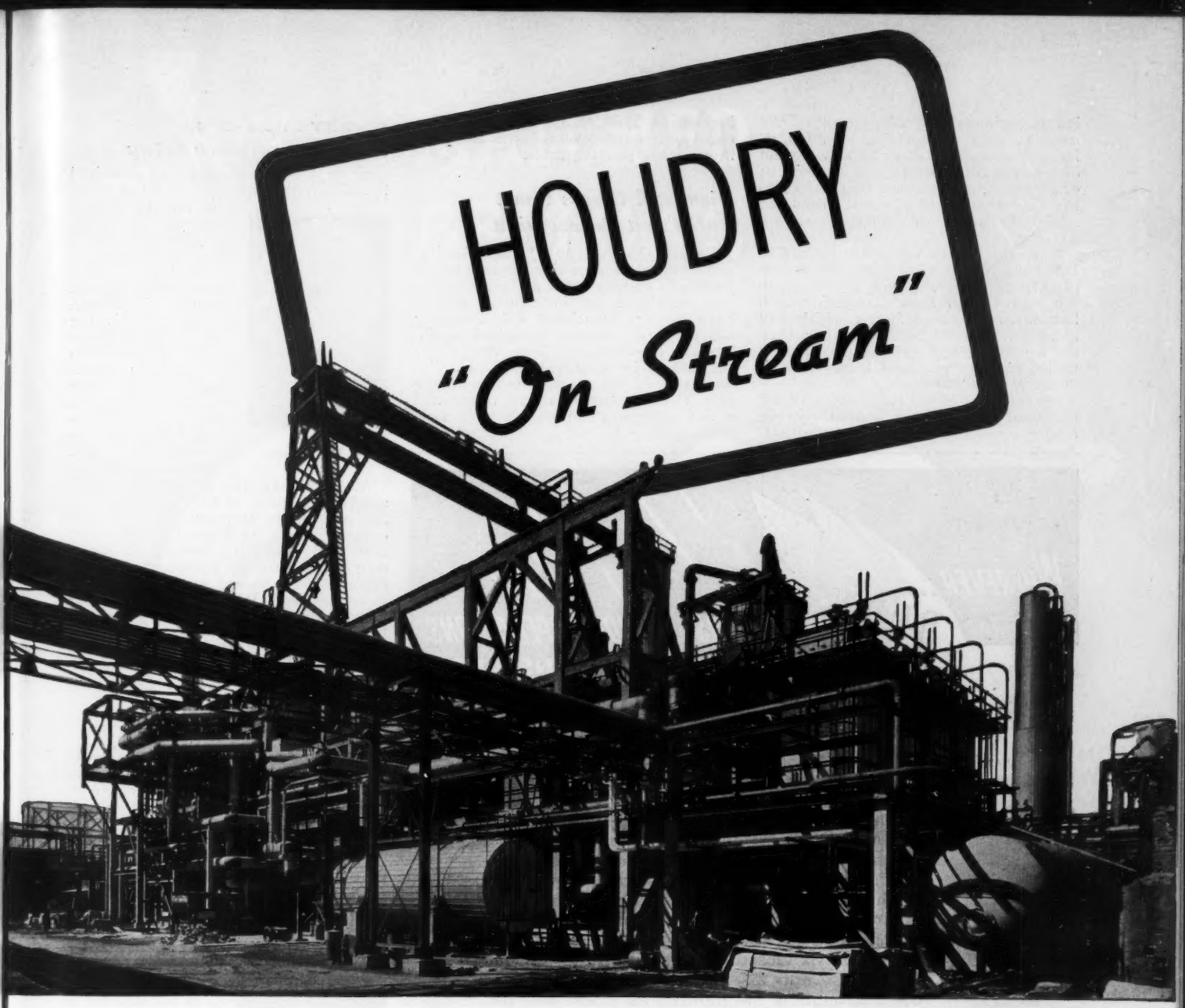
LUMNITE linings guard the steel shell of stacks and flues against oxidation and the attack of sulphurous flue gases. The insulating property keeps down shell temperature and improves draft.

For detailed information, write for "LUMNITE in Stacks and Chimneys." Address Atlas Lumnite Cement Co. (United States Steel Corporation Subsidiary), Dept. R-8, Chrysler Bldg., New York City.



• Cross-section of steel stack, showing Lumnite protective lining, and a duct installation below built of Lumnite heat-resistant concrete lined with Lumnite insulating concrete.

LUMNITE FOR REFRACTORY CONCRETE



A recently completed run shows the following, a record for any catalytic cracking unit:

On Stream	200 days
Gasoline	48.9% (once thru)
Octane (clear)	86 (39 Research)
Liquid Recovery	94.6%

. . . and another unit reported in August the completion of 157 days "on stream" with 96.6% time efficiency.

This proved operating ability combined with a proved ability to produce aviation fuel for national defense makes the Houdry Catalytic Cracking Process of immediate interest to all refiners.

Licensing Agents for the Houdry Catalytic Cracking Process

E. B. BADGER & SONS CO.

Boston, Mass.

New York • Philadelphia • San Francisco • London • Paris

•

Engineers and Contractors
for Petroleum Distillation and Refinery Equipment

ing at refineries of 6.8 percent of the total refinery production, or 3,100,000 barrels, of natural gasoline and a yield of straight-run and cracked gasoline of 42.5 percent, the production of 42,200,000 barrels will require crude runs of 99,310,000 barrels, or 3,546,800 barrels a day.

The estimate for foreign crude run to stills has been lowered 200,000 barrels to 3,500,000 barrels, and the estimate for exports has been dropped 400,000 barrels to the same figure, which still is almost 200,000 barrels higher than the actual for last February. Crude oil to be used as fuel and losses is estimated at 2,300,000 barrels.

On the basis of the above calculations, the total demand for domestic crude for the coming month will be 101,610,000 barrels, or 3,628,900 barrels daily, allocated among the several states as shown in an accompanying table.

Dismissal Closes Coast Anti-Trust Prosecution

Federal Judge Paul J. McCormick, acting on motion of the Department of Justice in district court at Los Angeles, has dismissed an indictment against Tide Water Associated Oil Company charging the company conspired to violate the Sherman act. Tide Water was the last major company still under indictment, having elected to contest the suit. Other companies had terminated action against them on pleas of nolo contendere.

Standard of Texas Changes Executive Setup

H. D. Collier, president of Standard Oil Company of California, last week was named board chairman of Standard Oil Company of Texas in a plan of centralizing active management of the company in Texas. Collier, who is the only one of the company's officers who will make his headquarters outside the state, continues as president of the California company, with headquarters in San Francisco.

H. D. Collier

A. J. Cunningham, who joined Standard Oil Company of California 18 years ago at Billings, Montana, and has been connected with its Texas operations for the past 13 years, has been named president of Standard Oil Company of Texas. Other officers named were E. H. Todd, vice president; R. G. McIntyre, secretary and treasurer; G. M. Foster and G. J. Osborn, assistant secretaries, and H. C. Judd and R. P. Redman, assistant treasurers.

Dickey President of General Petroleum

Upon the retirement of A. L. Weil, S. J. Dickey was elected president of General Petroleum Corporation, Los Angeles.

His advancement came after 21 years with the company, which he joined in 1919 as a refinery engineer. A year later he became chief engineer. He became a director in 1927 and in 1930 was elected vice president in charge of manufacture.

S. J. Dickey

Dickey is a graduate of the University of Pennsylvania, a member of the American Society of Mechanical Engineers, the American Petroleum Institute and the Army Ordnance Association.

Previous to his affiliation with General Petroleum Corporation, he had service in various engineering capacities, first during school years with the Pennsylvania Railroad, Bell Telephone Company and University of Pennsylvania. For eight years following his graduation, he served as traveling plant efficiency engineer and superintendent of development work, for United States Improvement Company of Philadelphia. In 1912 he was appointed engineer and superintendent of Syracuse Lighting Company, Syracuse, New York, where he directed design, installation and operation of a toluene plant, to make toluene from manufactured gas for the production of TNT. This led to his appointment by the War Department to direct installation of toluene plants on the Pacific Coast.

Retiring President A. L. Weil, one of the most widely known men in the oil industry, has experienced a long and colorful career in the oil industry.

WHEREVER... BURN HAZARDS... EXIST IN YOUR OPERATIONS ... HERE IS INSTANT PROTECTION and RELIEF!

M.S.A. FIRE BLANKET

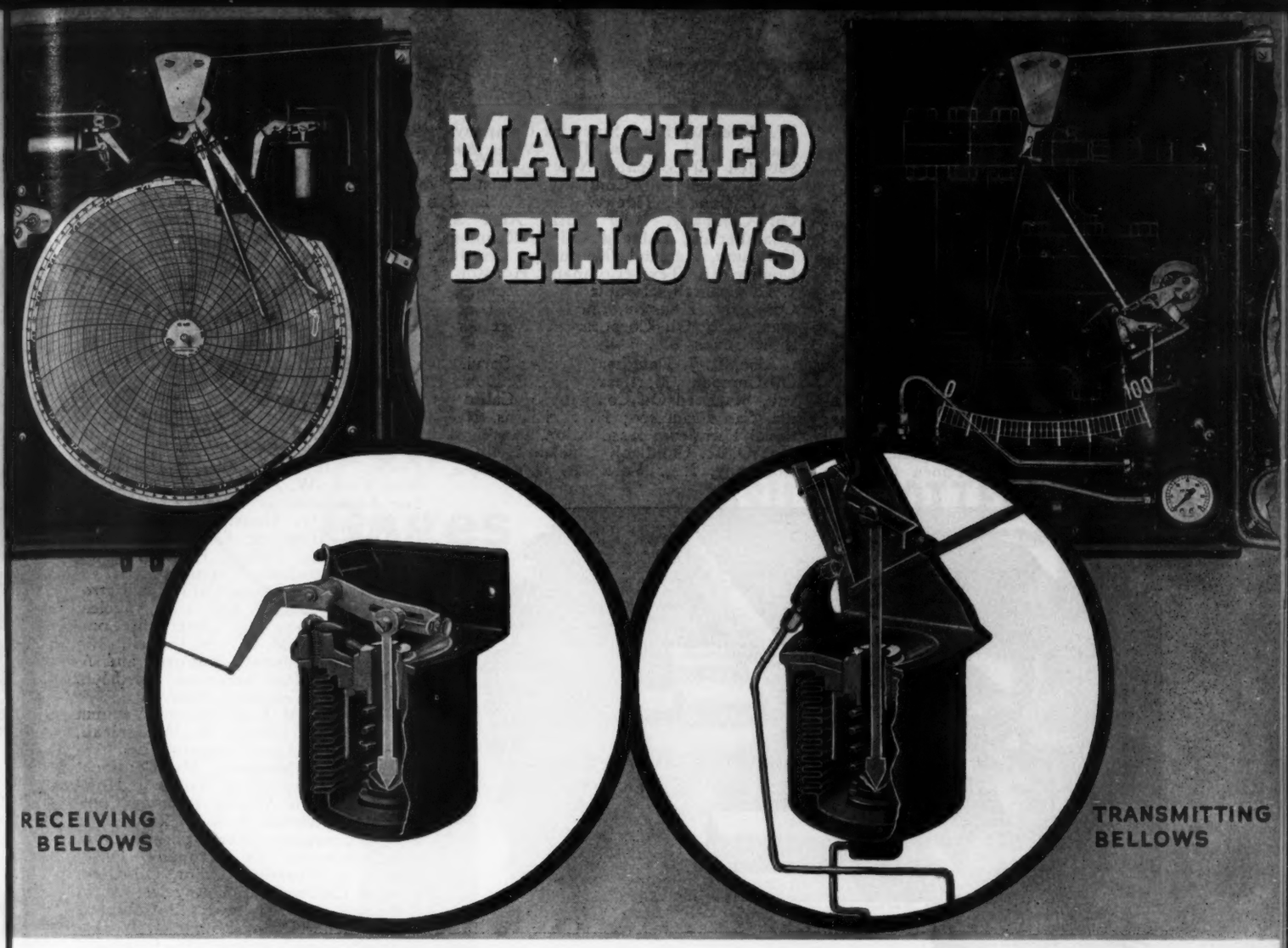
Extends and envelopes the victim of fire in a single rapid movement, providing head-to-foot coverage and extinguishing the flames with maximum speed and efficiency. Always ready for use, the fireproofed M.S.A. Fire Blanket is strung on a bar in the vertically-mounted metal case, with a hand-loop of treated rope positioned outside when door is closed. A single pull on the loop opens case and extends the Blanket—instantly! Used throughout the industry for finest *on-the-job* protection. Write for Bulletin No. FA-63.

M.S.A. FOILLE SPRAY KIT for BURNS

A *new, complete,* emergency burn treatment kit, scientifically designed to provide every advantage of the spray technique in applying Foille for Burns. Ready at all times for immediate service (no solutions to make or ingredients to mix), the spray gun quickly attaches to a jar of Foille and produces a continuous fine spray, to quickly and effectively cover burned area. Extra jars of Foille, plenty of unit-packaged compresses, bandages, pads, a sterilized muslin sheet, brush and other accessories are included in the sturdy All-Weather kit. Foille is good until used—does not deteriorate. Ideal for refineries, compressor stations and other points. Full details in new Bulletin No. FA-73.

Demonstrations Gladly Arranged on Request

MINE SAFETY APPLIANCES COMPANY
BRADDOCK, THOMAS AND MEADE STREETS, PITTSBURGH, PA.
District Representatives in Principal Cities



Insures Accurate Calibration

All Brown "New-Matic" Systems are equipped with identical bellows in both the transmitting and receiving instruments. These bellows are factory "matched" to rigid specifications, insuring accurate calibration throughout the pressure range.

RESPONSE

Rapid rate of response is obtained through the use of a new non-bleed pilot. With tubing lengths as great as 1,000 feet, the receiver pen will travel through full scale at a rate equivalent to the most rapid rate of mercury differential change ever encountered in flow meter practice. With the thermometer transmitters it has been proven that the response is even more rapid than with long lengths of capillary.

ACCURACY

Positioning of the recording pen is guaranteed to within 1/10 of 1% of full scale range. Precision workmanship in all moving parts eliminates any appreciable hysteresis errors. The system is unaffected by ambient temperature changes of fluctuating air supply pressure.

POWER

The extra large spring and bellows design insures ample power for pen positioning and control mechanism operation. There is no "pen drag" or tapping error.

The Brown "New-Matic" Remote Transmission System is safe, stable, accurate and powerful, and lends itself admirably to the growing demand for centralized recording and control without any of the drawbacks attendant to long lengths of meter piping or capillary tubing, and where the use of electricity is not desirable.

SEND FOR CATALOG 9400

Write THE BROWN INSTRUMENT COMPANY, a division of Minneapolis-Honeywell Regulator Co., 4498 Wayne Avenue, Philadelphia, Penna. Offices in all principal cities. Toronto, Canada: 117 Peter Street—Amsterdam-C, Holland: Wijdesteeg 4—England: Wadsworth Road, Perivale, Middlesex—Stockholm, Sweden: Nybrokajen 7.

BROWN *NEW-MATIC* TRANSMISSION SYSTEM

FOR TEMPERATURES ... PRESSURES ... FLOWS ... LIQUID LEVELS

R. W. Black Heads A.P.I. Accident Prevention Group

R. W. Black, chief safety engineer for Standard Oil Company (New Jersey), Elizabeth, New Jersey, has been appointed chairman of the American Petroleum Institute's Central Committee on Accident Prevention for 1941. He succeeds J. Howard Myers, The Atlantic Refining Company, Philadelphia. Members of the committee, as appointed by Executive Vice President W. R. Boyd, Jr., are:

D. A. Bering, Shell Oil Company, San Francisco; J. C. Bernd, Sinclair Refining Company, East Chicago, Indiana; H. W. Boggess, Sinclair Prairie Oil Company, Tulsa; J. S. Boylan, Continental Oil Company, Ponca City; A. W. Breeland, Lone Star Gas Company, Dallas; J. H. Brown, Tide Water Associated Oil Company, New York; Glen Byers, Shell Oil Company, Houston; S. W. Candee, Tide Water Associated Oil Company, New York; Alex S. Chamberlain, Ashland Oil & Refining Company, Ashland, Kentucky; Lee B. Conner, The Texas Company, Houston; J. H. Cuthrell, Humble Oil & Refining Company, Houston, and C. W. Coleman, Gulf Oil Corporation, Port Arthur, Texas.

Also, R. J. Daugherty, Cities Service Oil Company, Bartlesville; R. E. Donovan, Standard Oil Company of California, San Francisco; H. S. Elkins, National Petroleum Association, Washington; O. H. Gundlach, Sinclair Refining Company, New York; R. G. Guthrie, Sun Oil Company, Philadelphia; John Hammerman, Jr., Gulf Oil Corporation, Houston; Frank Harrison, The Pure Oil Company, Chicago, W. V. Hartmann, Gulf Oil Corporation, Pittsburgh; R. T. Henderson, Standard Oil Company (Ohio), Cleveland; J. E. Heston, Petroleum Advisers, Inc., New York; C. L. Hightower, United Gas Pipe Line Company, Shreveport, and J. M. Ivy, Standard Oil Company of Louisiana, Shreveport.

Also, H. W. Jackson, Kendall Refining Company, Bradford, Pennsylvania; J. H. Kelley, The Atlantic Refining Company, Dallas; W. I. Kent, Magnolia Petroleum Company, Dallas; L. F. Knox, General Petroleum Corporation of California, Los Angeles; Oscar B. Lewis, Ethyl Gasoline Corporation, New York; W. F. Lowe, Natural Gasoline Association of America, Tulsa; T. S. Maffitt, Jr., Houston Oil Company of Texas, Houston; J. L. Manes, Sun Oil Company, Dallas; H. T. Markee, Phillips Petroleum Company, Bartlesville; A. J. Martinson, California Petroleum Safety Board, Inc., Los Angeles; J. D. McCamey, The Carter Oil Company, Tulsa; M. C. McDowell, Rio Bravo Oil Company, Houston, and A. M. McKean, Pan American Petroleum & Transport Company, New York.

Also, F. R. McLean, Socony-Vacuum Oil Company, Detroit; R. W. Metcalf, Signal Oil & Gas Company, Los Angeles; E. D. Murphey, Mid-Continent Petroleum Corporation, Tulsa; J. Howard Myers, The Atlantic Refining Company, Philadelphia; A. A. Nichoson, The Texas Company, New York, A. A. Odell, Barnsdall Oil Company, Tulsa; George F. Prussing, Union Oil Company of California, Los Angeles; W. P. Reymond, Jr., Standard Oil Company of Louisiana, Baton Rouge; J. L. Risinger, Socony-Vacuum Oil Company, New York; R. B. Roaper, Humble Oil & Refining Company, Houston; S. D. Saltonstall, Lion Oil Refining Company, El Dorado, Arkansas, and C. W. Smith, Standard Oil Company (Indiana), Chicago.

Also, J. P. Sutton, The Ohio Oil Company, Findlay; C. L. Swim, Skelly Oil Company, Tulsa; A. H. Vineyard, Shell Oil Company, New York; C. R. Weidner, Sinclair Refining Company, Independence, Kansas; Frank Werner, Republic Production Company, Houston; H. J. Wilson, Tide Water Associated Oil Company, San Francisco, and M. K. Youker, Phillips Petroleum Company, Bartlesville.

Carleton Ellis Dies in Florida

Carleton Ellis, inventor of the Tube and Tank cracking process, died January 13 in Miami, Florida, of influenza. He held the third largest total of United States patents, 733, and it is understood that many other applications were pending at the time of his death.

Among his many writings was "Chemistry of Petroleum Derivatives," an outstanding work that came out of petroleum research. His principal interests were in petroleum, paint, varnishes and synthetic resins.

He was born in Keene, New Hampshire, September 20, 1876. After graduation from Massachusetts Institute of Technology in 1900, he became a teacher in that school and remained until 1902. Then he helped to organize Ellis-Chalmers Company. Later he engaged

HI-TENSILE "C"
HI-TENSILE "F"
HI-TENSILE "G"
—3 of the Page Electrodes with specific qualities for specific welding jobs in carbon steel.

You can get a PAGE-ALLEGHENY *Stainless Steel* ELECTRODE that will give you weld metal in the weld equal to whatever stainless you weld.

it's PAGE rod for all welding

For every welding job you've got around the refinery or anywhere else, there is one PAGE ELECTRODE that has the characteristics you want.

You may be welding low carbon steel, high carbon steel or stainless steel.

It may be thin sheet or heavy plate.

It may require vertical, horizontal or overhead welding.

Uniformity, highest speed or greatest strength may be specified.

Whatever the combination of conditions, depend on your local PAGE Distributor to recommend the rod that will meet them best.

PAGE ELECTRODES

PAGE STEEL AND WIRE DIVISION • MONESSEN, PENNSYLVANIA

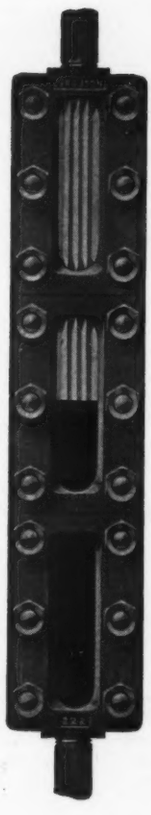
AMERICAN CHAIN & CABLE COMPANY, Inc.

★

JERGUSON

Reflex Gages

LIQUID LEVEL EASILY SPOTTED 50 FEET AWAY



WHITE
Shows Air or Gas Space

BLACK
Shows Liquid

JERGUSON Reflex Gages provide maximum visibility because of the sharp line of demarkation between liquid—any liquid—and the space above. It doesn't require especially keen eyesight to spot liquid levels even 50 feet away. Operators appreciate this higher visibility. They also like the assurance given by all JERGUSON gages of higher quality glass, strong metal chambers, and leakproof assembly.

JERGUSON GAGE & VALVE CO.

87 Fellsway Somerville, Mass.

in consulting work and became manager of Eldred Process Company. In 1907 Ellis-Foster Company was formed. A year later he opened Ellis Laboratories Inc. in Montclair, New Jersey, where most of his scientific researches were carried on.

He was a member of American Chemical Society. American Institute Chemical Engineers, Chemical Society of London and Chemists' Club, New York.

Bay City, Michigan, Plant Resumes After Remodeling

Essex Refining Company has gone back on stream after remodeling its straight-run plant at Bay City, Michigan. The plant is charging about 500 barrels of crude a day, taking it from the Wisner field, Tuscola County.

Atlantic Refining Company Fosters Refining Classes

More than 400 employes of the Point Breeze plant of The Atlantic Refining Company are studying the technology of processes in night classes in Philadelphia schools. The students are grouped in 14 classes. Text books are those used in the extension service of Pennsylvania State College. Reasons for the study have been described by H. R. Harris, personnel director of the Point Breeze plant as:

"Technological advances in petroleum refining made necessary the employment of the highest type of plant workers. A recent check of our plant personnel and supervisory staff showed that more than 60 percent are high school graduates. They are anxious to keep in touch with latest developments and for this reason have enrolled in the classes.

"Modern processes involve high pressures and high temperatures and operation of the equipment requires an understanding of the theory of these processes as well as a knowledge of their practical applications. These courses serve not only to fit our employes to perform their work better but also enable them to adapt themselves to new technological advances as they come along.

Bill Calls for Permanent Texas Proration Statute

Plans are under way to permanently incorporate Texas proration laws in the state statutes. A bill introduced in the Texas House last week would extend these laws indefinitely from their expiration date in September, 1941.

Proponents of permanent legislation declare the Texas law has been tried sufficiently to determine its value. The act was first passed in 1933, and has been amended at each session thereafter. However, amendments made in 1939 were largely corrective, and brought no major change in the policy or purposes of the act.

Another benefit which sponsors of the bill hope to derive from a permanent law is a stability that may be used in opposing federal control of the oil industry. They point out that instability has been one of the defects in Texas proration that has been subjected to federal criticism most frequently. By establishing a permanent statute, they hope to convince federal authorities that Texas plans to keep the industry under control.

In the past, it has been thought wise to enact the law for two-year periods so it might be possible to amend the law readily. The short periods have also been used to satisfy opponents of proration who viewed it as a major-company threat that might engulf them unless some terminal date was provided in the statute itself. Since proration has become generally accepted in Texas, much of the value of this argument is gone, and there is little apparent opposition to the re-enactment of the bill.

Compact Bill Considered Drastic

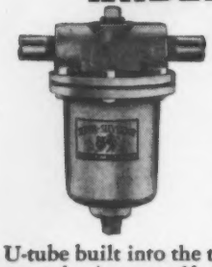
However, any consideration of legislative action on the Texas proration laws would be incomplete unless proper consideration and weight is given to the model law which has been proposed by the Interstate Oil Compact Commission. While this bill has not been introduced at Austin, it has several sponsors in the legislature who might well offer it as a substitute, either in committee meetings or on the floor. Because this bill defines property rights as well as providing control of oil and gas production, it is bound to cause considerable argument.

Indeed, some phases of this bill are so drastic and so in conflict with the views of many large and small producers that it is entirely possible no bill at all would be enacted rather than one providing for limitation of oil production for the prevention of physical waste.

These attitudes are well known to the proponents of the measure, and for this reason, they have indicated they might not offer the bill at this session. They have likewise taken into consideration

Traps sketched here are old style 1931 model Anderson steam traps with their piping. Below is a photo of the present model Anderson Super-Silvertop trap showing simplified piping.

UNTANGLE *that* RED TAPE PIPING *with* ANDERSON SUPER-SILVERTOPS



Why bother with "Red Tape" piping when you can untangle the jumble with Anderson Super-Silvertop—the straight-in-line inverted bucket steam trap? This engineered steam trap has the U-tube built into the trap—you don't have to make it yourself. That permits using the trap straight-in-line or as an elbow—no extra fittings to buy or install. Result?—neater piping layout and a saving of as much as seven fittings and an hour of installation time *per trap!*

Anderson Super-Silvertops also have greater condensate capacity, since a larger bucket and longer lever arm easily open a larger valve orifice and open it wide—the two essential items that determine trap capacity. In addition, Super-Silvertops have a record of long service life, positive operation, ease of inspection (trap stays on the line), exceptional valve life and are backed by 55 years of steam trap manufacturing experience.

Find out more about Anderson Super-Silvertop, the inverted bucket trap with simplified piping—send for your copy of the helpful book, "How To Choose a Steam Trap." Even if you don't use Super-Silvertops, you'll find this book valuable; write today.

THE V. D. ANDERSON COMPANY
1942 WEST 96TH STREET • • CLEVELAND, OHIO

Super-Silvertop
STEAM TRAPS

Two More **POLYFORM-GAS REVERSION UNITS**

by **LUMMUS**

Lummus is designing and building two Polyform-Gas Reversion units—one, 4600 barrels per day and the other, 7300 barrels per day of naphtha and outside propanes and butanes.

These are the thirteenth and fourteenth Polyform-Gas Reversion plants—including four now under construction by Lummus—with a total fresh feed charge of 67,000 barrels of naphtha, propanes and butanes.

Write for complete data on Polyform and Gas Reversion processes.

THE LUMMUS COMPANY, 420 Lexington Avenue, NEW YORK, N. Y.

600 SOUTH MICHIGAN AVENUE, CHICAGO, ILL. • 411 WEST FIFTH STREET, LOS ANGELES, CAL. 3028 WROXTON AVENUE, HOUSTON TEXAS

BUSH HOUSE, ALDWYCH, LONDON, W. C. 2 FLORIDA 671, BUENOS AIRES, ARGENTINA

LUMMUS

PETROLEUM REFINING PLANTS

the fact that there has been introduced in the legislature a bill to create a new oil and gas commission which would administer the law.

A Texas Senate bill would provide that sweet gas could be used for carbon black when the gas comes from a reservoir which produces both sweet and sour gas. Recovery of the plant must be five pounds or more per 1000 cubic feet of gas used.

A new Arkansas bill, introduced in the Senate, would tax natural gas sold in the state on which no Arkansas severance tax has been paid, at 2 cents per 1000 feet. The seller would not be permitted to pass the tax on to the consumer. House bill would declare title to oil and gas in the natural state are not subject to transfer or conveyance separate and apart from lands.

In New Mexico, a House bill would compel the State Oil Conservation Commission to prorate production of gas wells. The author pointed out that the commission now had that power, but that unless it was exercised gas pressures would decline sharply and fields become exhausted.

Completion of a gasoline line from Port St. Joe, Florida, to Mount Lookout, Georgia, by Southeastern Pipe Line Company will be possible if the Georgia legislature approves two bills that would give pipe lines the right of eminent domain and the right to traverse public property. Completion of the Florida section of the line was realized last year.

GRAY

IS ADAPTABLE TO LARGE OR SMALL PLANT REQUIREMENTS

Refiners operating units ranging in capacity as low as 100 barrels per day and as high as 30,000 barrels per day have found Gray Clay Treating a low cost method of producing a quality, low gum content gasoline.

Refiners striving for low cost production will do well to consider the Gray Clay Treating Process.

GRAY

THE GRAY PROCESSES CORPORATION

Licenses granted under United States and Foreign Patents by The Gray Processes Corporation

26 JOURNAL SQUARE · JERSEY CITY, NEW JERSEY

CLAY TREATING

Lederer Resigns as Bradford President

Dr. E. R. Lederer resigned as president of Bradford Oil Refining Company, Bradford, Pennsylvania, last month. He had held the position as well as that of general manager since 1936. During that time the plant was modernized.

His connection with the refining industry began in 1912 when he became assistant to the chief chemist of Standard Oil Company of New Jersey at Bayonne. Previously he had been with Vacuum Oil Company in Galicia and Roumania.

In 1914 he became chief chemist and general manager of the plant of The Atlantic Refining Company at Franklin, Pennsylvania. His connection with Galena Signal Oil Company in 1916 was followed by construction of the first refining plant on the Houston Ship Channel. From 1919 to 1921 he was manager of the oil department of Atlantic Gulf Oil Corporation with headquarters in New York. From 1922 to 1925 he was vice president of Louisiana Oil Refining Corporation at Shreveport, where he supervised construction of the first vacuum plant for naphthene-base lubricating oils. He was vice president of Texas Pacific Coal & Oil Company from 1925 until January, 1935, when he became chairman of the labor subcommittee of the Planning and Coordination Committee of the National Industrial Recovery Act.

Reorganization Plan Approved

The tenth Circuit Court of Appeals has approved reorganization plans for Deep Rock Oil Corporation, as prepared by Henry N. Gries, trustee. The action came on appeal of Standard Gas & Electric Company, a creditor, after Judge Franklin E. Kennamer of Federal District Court for Northern Oklahoma had approved the plan.

Rock Island Refining Company To Build Plant at Indianapolis

Rock Island Refining Company has been organized as an Indiana corporation to construct a 5000-barrel capacity cracking plant on the outskirts of Indianapolis. Completion of the project is scheduled for August 15, and crude from both Mid-Continent and Illinois fields will be taken through existing pipe-line facilities.

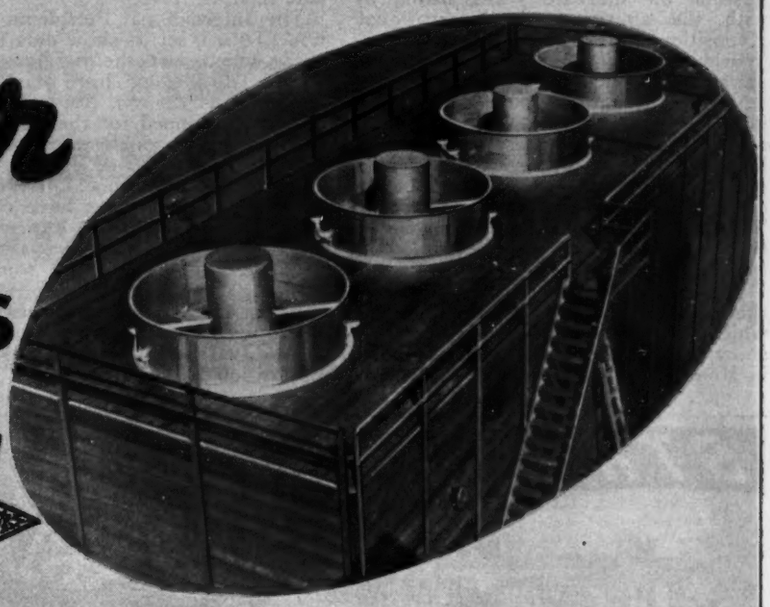
Officers are L. B. Simmons, of Rock Island Refining Company, Duncan, Oklahoma, president; L. S. Winkler, of Winkler-Koch Engineering Company, Wichita, vice president, and L. E. Kincannon, vice president-secretary.

Two Oil Shows Are Planned During 1942

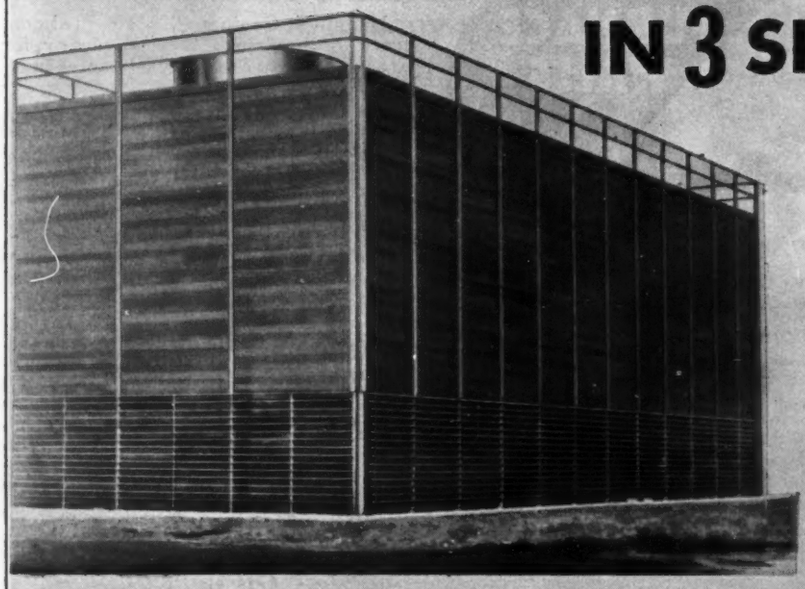
Notices have been sent out to members of Oil-World Exposition asking them to attend an important meeting of the membership at the Rice Hotel, Tuesday noon, February 25. Oil-World Exposition is a chartered non-profit corporation, created to hold oil expositions in Houston. Membership is composed of oil men and manufacturers.

Houston and Tulsa have expositions scheduled within a month of each other

THE *Tower* THAT SAVES YOU MONEY



IN 3 SPECIFIC WAYS



1. Counter Flow Cooling Efficiency
2. Low Head Pumping Economy
3. Non-corrosive Fans One-half the Usual Weight.

These features are easily recognized as money savers. Counter flow design brings air in where water goes out and results in the coolest air coming in contact with the coldest water.

Low pressure water distribution and low tower height mean correspondingly low pumping head.

Non-corrosive monel fans are one-half usual weight—don't pit—last longer—save power—reduce driving gear wear. An exclusive Pritchard feature. Write for new Bulletin No. 40-A.

J. F. PRITCHARD & COMPANY
Dwight Building Kansas City, Mo.

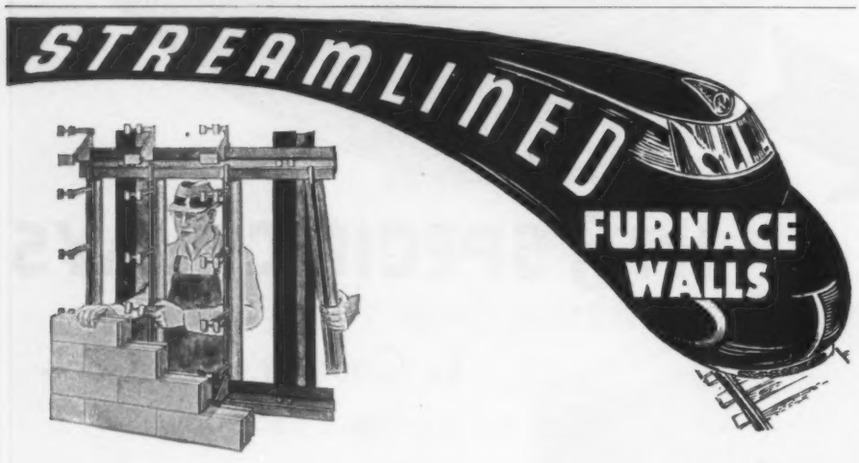
BRANCH OFFICES IN TULSA, OKLA.; HOUSTON, TEXAS; CHICAGO, ILL.; COLUMBUS, OHIO; ST. LOUIS, MO.

PRITCHARD
Atmospheric and Mechanical Draft
WATER COOLING TOWERS

in 1942. Houston formerly held an exposition on alternate years, fitting in with the alternate-year International Exposition at Tulsa. In 1939 the Oil-World Exposition sent out a questionnaire to oil-company executives asking what they thought about frequency and location of oil expositions. Most of the replies indicated that these executives favored only two shows in a four-year period and the majority of them indicated a willingness for Houston and Tulsa to divide the oil show business, some refusing to express an opinion as to location of shows.

The Houston exposition membership then voted to skip showing in 1941 which, under previous custom of an oil show every year, one in Tulsa and one in Houston, would have been the Houston year, and set its next exposition date in April, 1942.

The International Petroleum Exposition (Tulsa), set its show date for May, 1942, which was the regular year on which Tulsa would have shown under the previous custom. Net result is two oil shows planned for the same spring, with a war on and few manufacturers keen to show in both places the same year even in peace time. Oil-World Exposition representatives have contacted International Petroleum Exposition executives, trying to get Tulsa to agree to have a show once in four years, pledging that Houston also will have only one show in each four-year period, which would mean oil shows only on alternate years. International Petroleum Exposition officials take the position that they started the idea of oil shows, have a plant in which to hold shows, have changed from an every-year-at-Tulsa basis to an alternate-year-at-Tulsa basis, and that is as far as they feel they should go.



LIGHT
TIGHT
TOUGH
CHEAP

Engineered from the ground up—stripped of unnecessary material and weight—trimmed down to a slim thinness—THINSULITE Furnace Walls are really streamlined.

A complete integral construction combining first grade refractory, ample insulation, and a strong supporting frame, provides a wall that is at once permanent, flexible and heat and air tight.

At the price of ordinary brick you can now have a modern sectionally supported wall—and arch—one that gives you assurance of uninterrupted operation and long life.

THINSULITE is suitable for use in any furnace, on all areas where abrasion, spalling or slagging are not likely. Detred construction is recommended for the heavy-duty areas.

Thinsulite
WALLS and ARCHES

See the heat transfer curves shown in the THINSULITE Catalog sent on request.

M·H·DETRICK COMPANY
140 S. DEARBORN STREET, CHICAGO

Refining Calls For Chemicals

Interrelation of chemical processing industries is evident from a study of a summary of a Census of Manufacturers for 1939. The brief summary makes comparisons between 1939 and 1937.

For instance petroleum refining called upon the chemical industry for 505,592 tons of sulphuric acid in 1939. In that year the petroleum industry was making 204,847 tons of 50° Baume sulphur and at the same time it was reclaiming and using 214,150 tons of this acid, basis 50° Baume.

The soda ash requirement for petroleum refining in 1939 was 11,363 tons.

The caustic soda requirement for that year was 99,297 tons.

Union Oil Company Awards Tanker Contracts

Union Oil Company has awarded contract to Bethlehem Steel Company for construction of two 130,000-barrel tankers. Delivery is scheduled for 1943. The ships will be 500 feet long, have a moulded breadth of 68 feet and moulded depth of 37 feet, with deadweight carrying capacity at summer freeboard of 16,400 tons. Displacement in salt water will amount to 21,500 tons.

The company has one other ship under construction, has placed contracts during the past year for two other ships to be delivered in 1942.

Warren Petroleum Installs Copper Sweetening Plant

Warren Petroleum Company has completed erection of a Perco solid-process type copper sweetening unit for its natural gasoline plant at Salem, Illinois. The unit will treat the plant's entire output of natural gasoline and liquefied petroleum gases.

Canadian Oil Consumption Up 15 Percent During 1940

Canadian consumption of petroleum products increased approximately 15 percent in 1940 over the 1939 figures, which had established a record up to that time, according to a year-end report by G. Harrison Smith, president Imperial Oil Ltd. and International Petroleum Company Ltd., at Toronto. The total domestic consumption in 1940 was approximately 53,000,000 barrels, compared to 46,000,000 barrels in 1939.

The increased demand was not entirely due to war requirements. While the Canadian oil industry satisfied large and urgent needs for the naval, military and air arms and for the expanding industrial activity to supply other munitions of war, another important factor was the record crop harvested in Western Canada.

The trend of petroleum product prices has been in contrast with the trend of general commodity prices, and gasoline is one of the very few major commodities which today sells for less than before the outbreak of war. This divirgence from the general price trend is

KELLOGG HAS THE SOLUTION TO MANY PROBLEMS FACED BY THE REFINER TODAY

Faced with today's conditions, refiners should recognize the fact that only an organization versed in all phases of refining technology and with a background of commercially successful installations covering a wide variety of processes can solve their problems. Many refiners have formed a habit of consulting The M. W. Kellogg Company as new problems arise. They have found this both satisfactory and profitable.

KELLOGG

LICENSING AND CONSTRUCTION AGENTS under United States and foreign patents for:
Catalytic Processes for Cracking, Reforming, Dehydrogenation, Alkylation, Desulphurization

- Gasoline Products Company, Inc., Pyrolytic Cracking
- The Polymerization Process Corporation, Thermal and Catalytic Polymerization
- JUIK Processes for Lubricating Oil Refining with Propane and Phenol Deasphalting · Dewaxing · Solvent Extraction and Acid Treating Plants
- The Gray Processes Corporation, Clay Treating

THE M. W. KELLOGG COMPANY · JERSEY CITY, NEW JERSEY · 225 BROADWAY, NEW YORK
Los Angeles: 609 South Grand — Tulsa: Philtower Building
EUROPEAN REPRESENTATIVE: Compagnie Technique des Petroles, 134 Boulevard Haussmann, Paris, France.

accounted for in part by technologic progress and part by volumetric competition.

Increased plant construction during 1940 will take care in part for import restrictions on petroleum products from non-sterling countries which went into effect in December, 1940. Early this year the largest refinery, situated in southern Ontario, will begin to receive some 10,000 barrels daily of South American oil, which will be transported by tankship to Marcus Hook, near Philadelphia, and then by pipe line nearly 700 miles to southern Ontario. This South American oil will displace an equivalent amount formerly imported from the United States now restricted to save United States dollars. Refining at this plant will also eliminate importation from the United States of certain types of lubricating oils.

Developments in the Turner Valley, Alberta, oil field continue to conserve the Canadian petroleum industry's exchange requirements. Thirty-seven new wells were completed in 1940, compared to 34 in 1939. Initial flow of wells drilled in 1940 ranged under government test from 162 to 3577 barrels daily. It is hoped that the new production thus secured is approximately adequate to maintain the Turner Valley's potential at a level that will permit efficient production of normal Prairie market requirements during 1941.

Owing to the Foreign Exchange Control Board's restrictions on payment of certain types of dividends the major oil refining and distributing group showed a drop of some $17,250,000 in the aggregate dividend payments for 1940, according to J. Scott Rattray, statistician of the Toronto Stock Exchange. Nevertheless, the group remained the third largest dividend payer on the exchange with $38,636,010 paid out to shareholders.

GET
EXTRA
POWER
WITH WILSON EP CLEANERS

If you want quicker, better, more economical tube cleaning put a Wilson E P (Extra Power) Series tube cleaner to work. It will remove the heaviest and hardest coke or scale, or the stickiest, gummiest deposit from refinery tubes and pipes.

When you see an Extra Power tube cleaner at work you'll admit it is well named because, while it uses from 25% to 40% *less air*, it actually delivers from 30% to 75% *more power* than ordinary tube cleaners of the same size.

Write for the name of our representative nearest to you or send for a copy of our new thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.

Export Licensing Extended to Well and Refinery Machinery

Moving to keep all possible war material out of unfriendly hands, President Roosevelt on February 4 approved a recommendation by Colonel Russell L. Maxwell, administrator of export control, and issued a proclamation placing oil well and refining machinery under the export licensing system. The control was effective February 10.

The President's proclamation carried another step further the plan of controlling petroleum exports initiated July 26, last, with an order placing aviation gasoline and aviation lubricating oil and tetraethyl lead under the licensing system.

This order was followed on September 16 by a proclamation restricting the export of equipment for the production of aviation motor fuel or tetraethyl lead and plans or specifications for such equipment, and on December 20 by another order extending the control to equipment and plans for equipment for the production of aviation lubricating oil.

Distillate for A.P.I. Program

Two papers on distillate recovery and testing will be on the program of the Southwest District, American Petroleum Institute's Division of Production at Shreveport February 27 and 28.

One subject will be "Analysis of Distillate Plants," the other, "Testing of Gas to Determine Feasibility of a Recycling Plant." Speakers will be announced later.

Annual Meeting At Kansas City

The annual meeting of the petroleum division of the American Society of mechanical engineers will be held in Kansas City, June 16-21.

Egloff Again Heads Exposition Committee

In accepting chairmanship of the technical committee of the International Petroleum Exposition for 1942 Dr. Gustav Egloff undertook direction of the exhibit for the third time. Co-chairman will be B. B. Weatherby of Tulsa. Egloff is director of research for Universal Oil Products Company, Chicago and Weatherby is in charge of geophysical research for Amerada Petroleum Corporation, Tulsa. The Hall of Science display will be enlarged for the 1942 exposition in Tulsa.

Clinton D. St. Clair has been appointed works manager of Manning, Maxwell & Moore, Inc.'s Hancock Valve Division plant in Boston. After attending Purdue University and Pennsylvania State College, he was with B. F. Goodrich Rubber Company, Ohio Match Company, Erie City Iron Works and American Machine & Metals, Inc.

A COMPLETE RANGE OF ALLOYS

1¼% to 27% CHROMIUM

Alloys for Each Type of Service

Economy through Proper Application

Technical Data on Request

BABCOCK & WILCOX TUBES

HOT FINISHED COLD DRAWN ALLOY STEELS CARBON STEELS

THE BABCOCK & WILCOX TUBE COMPANY, BEAVER FALLS, PA.

SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Heats of Formation of Gaseous Hydrocarbons, F. D. ROSSINI, *Chem. Rev.* **27** (1940) pp. 1-16.

The author selects and presents what he considers the best values for the heats of formation of 8 alkanes, 16 alkenes, and 3 alkynes, in the gaseous state at 25°K. The regularities and irregularities in the heats of formation, and in the changes of these heats with structure, are discussed.

Some Free-Energy Data for Typical Hydrocarbons Containing Six or More Carbon Atoms, G. S. PARKS, *Chem. Rev.* **27** (1940) pp. 75-83.

The molal free energies of formation at 25°C. were calculated for about 30 typical hydrocarbons containing 6 or more carbon atoms per molecule by means of the third law of thermodynamics and almost entirely with the aid of modern thermochemical data. In the paraffin series the free energies are given closely by the relationship $\Delta F^{\circ}f = -8912 + 1243n$, in which n is the number of carbon atoms in the molecule. The free-energy levels of the isoparaffins are slightly lower than the normal paraffins. The introduction of a double bond to form an olefin raises the molal free energy approximately 20,000 calories. The free energies of the cycloparaffins are between those of the paraffins and the olefins. The free energies of the aromatic hydrocarbons are higher than those of the olefins. Whenever the symmetry of a ring hydrocarbon is broken by the introduction of a paraffinic side chain the molal free energy is lowered 1000 to 3000 calories. Increases in the length of the side chain which give an increment per CH_2 group similar to that found in the normal paraffin series. The free-energy contribution of the phenyl group averages about 31,600 calories.

Chemical Equilibria, Free Energies and Heat Contents for Gaseous Hydrocarbons, K. S. PITZER, *Chem. Rev.* **27** (1940) pp. 39-57.

Statistical methods for calculating the thermodynamic functions of hydrocarbons are considered. A procedure especially suited to the complex hydrocarbons and the present incomplete knowledge of their molecular constants is described. The heat and free-energy functions for all the paraffins through the heptanes and for the simpler unsaturated hydrocarbons are presented in tabular form.

Velocity of Compressional Waves in Petroleum Fractions at Atmospheric and Elevated Pressures, R. MATTESON AND C. J. VOGT, *J. Applied Phys.* **11** (1940) pp. 658-65.

The samples included oils ranging in properties from light gas oils to viscous lubricating and residual oils, and in viscosity index from — 55 to + 100. Measurements were made on 37 samples at 100°F. and atmospheric pressure. The data obtained are presented in the form of curves, and for their interpretation require only a knowledge of specific gravity and kinematic viscosity at 100°F. Velocity-temperature curves are included for a few hydrocarbons at atmospheric pressure. Five of these samples were also tested at 4 temperatures between 57° and 210° F. and at pressures between 500 and 600 pounds per square inch.

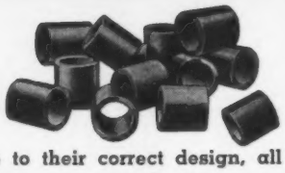
Thermal Stability of Furfural, A. P. DUNLOP AND F. N. PETERS, JR., *Ind. & Eng. Chem.* **32** (1940) pp. 1639-41.

Furfural is used in several processes at elevated temperatures, and the desirability of quantitative data relative to the thermal stability of furfural is evident. Experiments were designed to show the rate of decomposition of furfural. They can be divided into two main classes on the basis of the conditions used: first, a comparison of the stability of furfural at 140°, 180° and 230°C.; and, a measure of the effect of metals on the stability of furfural at 230°C. The data presented show that under the conditions of the experiment refined furfural is stable. The rate of decomposition at 230°C. is so slow that from an industrial standpoint furfural may be regarded as thermally stable. No commercial process is known in which furfural is subjected to temperatures of 230-275° C. for more than a few minutes, and the data show that it is a matter of hours before a change in the properties of furfural can be detected. Decomposition of furfural in the presence of metals is not greatly different from the rates of decomposition in the presence of glass. Work that has not yet been

"U. S." RASCHIG RINGS

OF STONEWARE OR WHITE PORCELAIN

Offer Maximum Resistance to Corrosion and Thermal Shocks



● All "U. S. Stoneware" and white porcelain Tower Packing Rings are made of De-flired (Vacuumized) and Electrolyzed clays.

● Vitrified at 2500° F., they offer maximum resistance to solvents, alkalies and acids (except hydrofluoric acid), including hot oxidizing agents. They will not chip, spall or crumble—even when subjected to extreme and sudden thermal shocks.

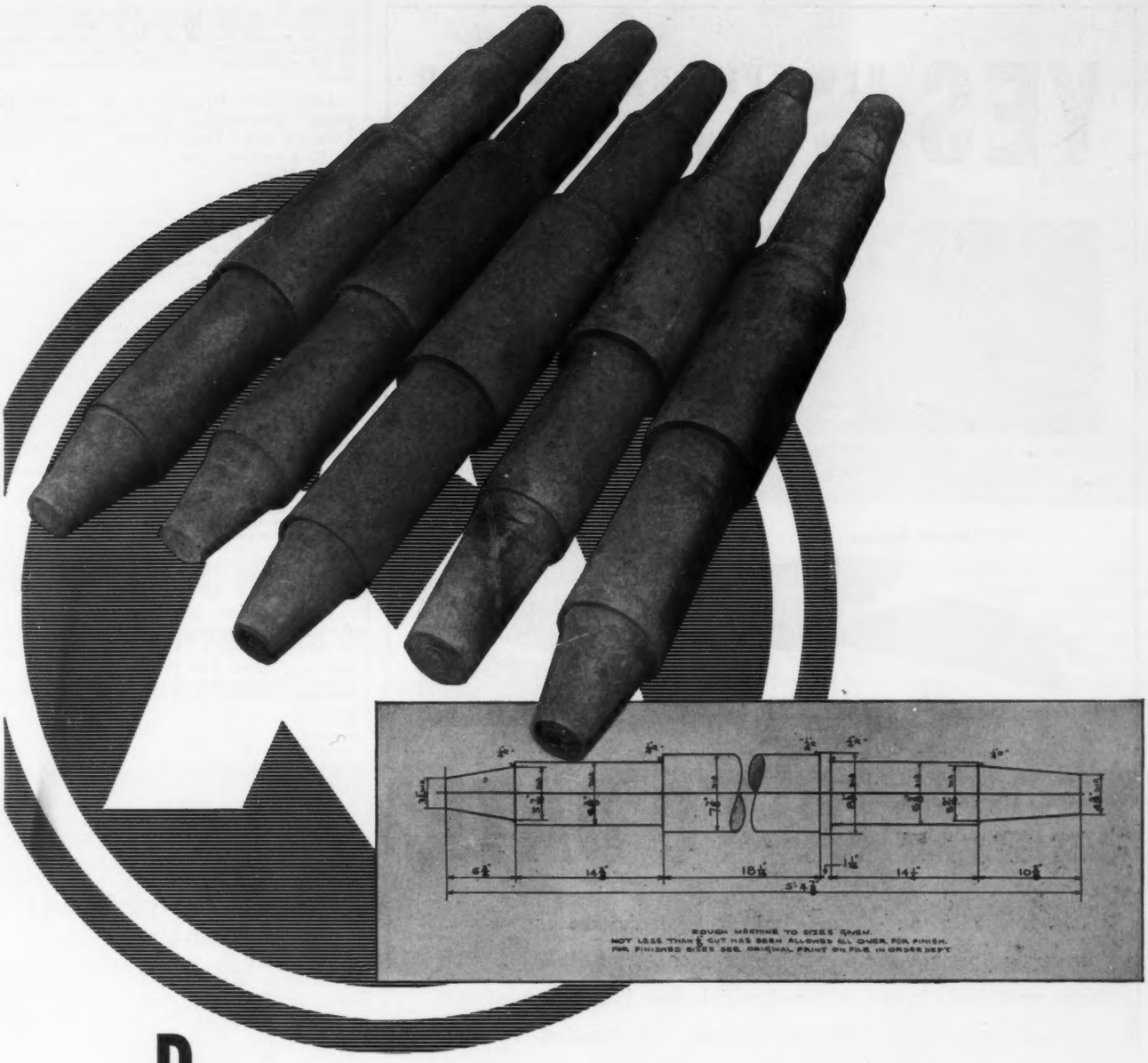
● Walls are all of uniform shape and thickness—non-absorbent, non-corrosive and non-porous. The White Porcelain Raschig Rings are practically iron-free and of almost zero porosity.

● Due to their correct design, all "U. S. Stoneware" and white porcelain Packing Rings are exceptionally strong. They will withstand a greater crushing stress than any others.

● We make a full line in all sizes from 1/4" O.D. up to 6" O.D. Prompt shipment can always be made from stock. Send for FREE SAMPLES today and test them in your own laboratory. See page 322 of 1940 Refinery Catalog for more information on U. S. Stoneware products.

THE U. S. STONEWARE CO.

WORKS (SINCE 1865) AKRON OHIO


ROUGH MACHINE TO SIZES GIVEN.
NOT LESS THAN ⅛ CUT HAS BEEN ALLOWED ALL OVER FOR FINISH.
FOR FINISHED SIZES SEE ORIGINAL PAINT ON FILE IN ORDER DEPT.

ROUGH MACHINED FORGINGS—or finish machined—of carbon steel, or any one of the many Midvale alloys . . . each product of The Midvale Company is made to definite specification because in that way only can it meet a specific requirement.

The Midvale Company, Nicetown, Philadelphia

OFFICES: *New York · Chicago · Pittsburgh · Washington · Cleveland · San Francisco*

MIDVALE

YES NEW APPLICATIONS FOR NEW REFINING PROCESSES

Special drum type filters

Above: 25' Diameter "Singledisc"— one homogeneous fabric

Below: Reactor Screens

Right: Spider Covers

MULTI-METAL DESIGNS ARE UP TO DATE

. . . And so is our plant in which we make the answers to many a filtering and screening problem. Then, too, our men are up-to-date in the skill with which they fabricate wire and screen assemblies. This exceptional coordination of right design, proper plant facilities, trained specialists, has enabled us for 30 years to maintain a reputation among refiners for solving the seemingly unsolvable filtering and screening problem. Today, it keeps us alert to changing conditions and enables us to give you new applications right in step with your new refining processes. In stock we carry a larger selection of weaves, metals, alloys, than you will find anywhere else. And, if yours is a special problem you can depend on us for quick and intelligent response to your particular needs. The hundreds of case histories in our "Book of Experience" prove that Multi-Metal means better results at less cost.

MULTI-METAL WIRE CLOTH COMPANY INCORPORATED 1356 GARRISON AVE., BRONX BORO, N. Y.

WIRE CLOTH
FILTER CLOTH
ALL MESHES
ALL METALS

completed indicates that when the moisture content of refined furfural is increased the rate of decomposition at 230° C. is increased. However, at 180° C. this increase in the rate is not noticeable, even after prolonged treatment.

Explosive Properties of Cyclopropane: Prevention of Explosions by Dilution with Inert Gases, G. W. JONES, R. E. KENNEDY AND G. J. THOMAS, *U. S. Bur. Mines Rept. Investigations* **3511** (1940) 17 pp.

The lower limit of inflammability of cyclopropane in air at ordinary temperature and pressure is 2.45 percent and the upper limit 10.45 percent by volume. The progressive addition of nitrogen narrowed the limits of inflammability; at 43 percent nitrogen all mixtures became noninflammable. Results on dilution with helium were similar. Neither of these gases exerted much effect on the lower inflammability limit. With carbon dioxide the limits converged to noninflammability at 31 percent. The upper limit was markedly affected by dilution with all 3 of these gases, but the lowering was almost directly proportional to the amount of inert gas added. The limits of inflammability of cyclopropane in oxygen were found to be 2.48 and 60.0 percent. The effect of diluents on cyclopropane-oxygen mixtures were studied, and the results are given. In cylindrical, closed bombs, the inflammable limits in air are narrower—2.58 to 10.1 percent by volumne. The maximum pressure was 98 pounds per square inch above atmosphere. The mixture contained 5.5 percent cyclopropane. The ignition temperatures decreased as cyclopropane concentration in air increased to a minimum of 498° at 10.74 percent. Ignition temperatures in oxygen are lower. Applications of the data to the problems of anesthesia are considered.

Identification and Determination of Aromatic Compounds in Mineral Oils, C. WEIZMANN, V. HENRI, AND E. BERGMANN, *Nature* **146** (1940) pp. 230-1.

The identification and determination of benzene, toluene, xylene, naphthalene, phenanthrene, and anthracene in mineral oils by the use of ultra-violet spectrography is described. It was found that the absorption spectra of these common aromatic hydrocarbons are sufficiently charactertistic to permit the estimation of them in petroleum. Iraq petroleum was examined by this method and found to contain 0.02 benzene, 0.31 toluene, 0.52 xylene, 0.30 naphthalene, 1.36 phenanthrene, and 1.76% anthracene. The Palestinian shale oil contained, respectively, 0.16, 0.18, 3.20, 4.60, 1.80, and 1.60% of the same compounds.

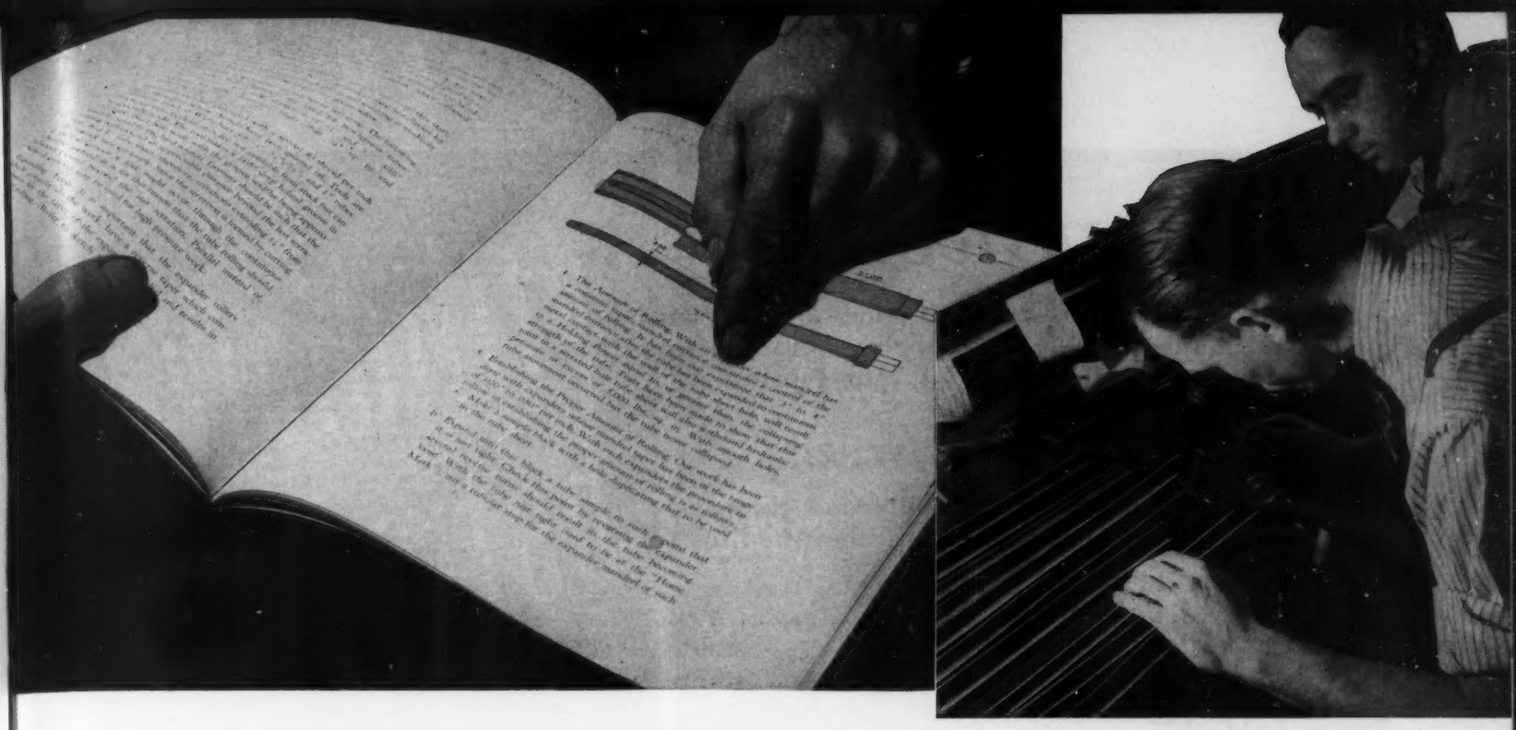
Chemical Compositions and Reactions

Hydrocarbon Chemistry. A General Discussion Reprinted from the Transactions of the Faraday Society. Book; pp. 287. Published by Gurney and Jackson, 98 Gt. Russell Street, London. Price, 12s, 6d.

The book covers the papers presented at the three-day discussion on Hydrocarbon Chemistry held by the Faraday Society. Part I covers the homogeneous thermal reactions of hydrocarbons, Part II, the catalytic reactions of hydrocarbons, Part III, the mechanism of the technical synthesis and transformation of hydrocarbons, and Part IV, olefin polymerization. Part I includes 10 papers, the first considering the structure and activation energies of hydrocarbons, and the remaining 9 considering the views held on the thermal reactions. This section is of particular interest to the petroleum technologist, for it deals with the basis of thermal cracking processes. In Part III two papers deal with the mechanism by which long-chain hydrocarbons are built from water-gas. The third paper considers coal-hydrogenation. Three papers deal with the cyclization of saturated straight-chain hydrocarbons to aromatics. A further paper considers the catalytic condensation of an olefin to an iso-paraffin, a procedure which it is believed is destined to have profound effect on petroleum technology. The fourth part, dealing with olefin polymerization, considers the formation of dimeric molecules, of medium-length molecules for use as lubricants, and of high-molecular-weight substances useful as plastics. The book is one of the best publications on hydrocarbon chemistry, and is of course of particular value to the research worker.

Synthesis and Properties of Mono-Normal-Alkylbenzenes. Part II—Preparation and Properties of the Intermediate Ketones and Corresponding Hydrocarbons, T. Y. JU AND C. E. Wood, *Jour. Inst. Petr.* **26** (1940) pp. 514-31.

A series of six mono-n-alkylbenzenes has



THE BOOK YOU HELPED TO WRITE

HELPS SOLVE

YOUR CONDENSER TUBE PROBLEMS

You may find in Scovill experience the answer to your Condenser Tube trouble, for Scovill's condenser service engineers have, for years, worked closely with condenser operators and manufacturers. They have encountered many and various problems—have helped solve many—kept records of all. In one, a Scovill consultant found the remedy in the addition of a small bleed line—inexpensive but effective in lengthening tube life.

In another case, a change in tube alloys made all the difference. This is particularly successful, where dezincification of Admiralty is encountered, for Scovill's patented Phosphorized Admiralty now greatly extends the life of that popular alloy by inhibiting dezincification.

In any problem involving Condenser or Heat Exchanger Tubing, these technical men stand ready to help you. If you are a Scovill customer —you have helped either directly or indirectly to provide the experiences which make Scovill's technical service possible.

SCOVILL CONDENSER TUBES

one product... three services

- **SERVICE IN MEN**
- **SERVICE IN METALS**
- **SERVICE IN MANUALS**

Scovill's new "Condenser Tube Booklet" which you have helped to write may save you time and money tomorrow.

This new booklet is free on request. It is part of Scovill's *service in manuals* containing complete, factual information. Other Scovill services to buyers of Condenser and Heat Exchanger Tubes are: *service in men* to consult with you in the field, and *service in metals* evolved in the laboratory to meet your needs. Scovill Manufacturing Co., 15 Mill St., Waterbury, Connecticut.

Scovill

MANUFACTURING COMPANY

WATERBURY, CONN.

To Improve Cast . . .

New Fluorescent Green produces a "Pennsylvania Cast" in lube oils. It is an additive which definitely will improve the salability of your lubricants.

New Fluorescent Green:

Solubility . . . . . readily and complete
Color . . . . . unchanged by transmitted light

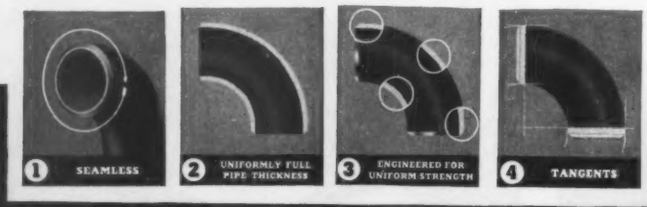
STABILITY:
light . . . . . fast
heat . . . . . stable
storage . . . . . stable

TESTS:
carbon residue . . . . . unchanged
fire . . . . . unchanged
flash . . . . . unchanged

Leading lube refiners in the United States and abroad have used Wilmot & Cassidy products for the past ten years. ***For samples, prices, and information please write to:***

Wilmot & Cassidy, Inc.

108 PROVOST ST. **BROOKLYN, NEW YORK**



TAYLOR FORGE

EACH one of these features guards against trouble and delay on the job. You'll find them combined only in WeldELLS

Seamless Pipe Fittings **WeldELLS** **For Faster Easier Welding**

TAYLOR FORGE & PIPE WORKS: General Offices and Works: Chicago, P. O. Box 485
New York Office: 50 Church St. Philadelphia Office: Broad Street Station Bldg.

been prepared from the corresponding ketones by palladium catalytic hydrogenation or by Clemmensen's reduction. It was found that the palladium catalytic hydrogenation method gives excellent yields and pure products. The ketones were prepared from the corresponding acid chlorides and benzene by means of the Friedel and Crafts' reaction. The yield of ketones decreased with molecular weight of the alkyl group. The optimum conditions for effecting the reaction were studied and are recorded. It was found that density and refractive index vary linearly with temperature, both for the ketones and the hydrocarbons. The effects of increasing chain length on the physical properties of both ketones and hydrocarbons are systematically recorded. The phenyl group has a profound influence on the physical properties of the n-alkylated benzenes even when the alkyl chain is long. The boiling point of the ketones increases on ascent of the series, but the melting point is irregular. Both boiling point and melting point of the hydrocarbons increase with ascent of the series. Increase of chain length increases the viscosity of the n-alkylbenzenes. This is more marked for the higher members than for the lower, and for the lower temperatures than for the higher. Detailed tabulations of the properties of the substances prepared are presented.

The Action of Elementary Fluorine Upon Organic Compounds. IX. The Vapor Phase of Fluorination of Methane, E. H. HADLEY AND L. A. BIGELOW, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 3302-3.

The results of a study of the fluorination of methane are recorded. The reactions were effected over a copper gauze catalyst and the products separated by fractionation. It was found that under suitable conditions, as much as 45 percent of the liquid volume of the product could be obtained as products other than carbon tetrafluoride. All of the possible fluoromethanes, together with hexafluoroethane and octafluoropropane have been isolated from the products. The results are in accord with the current free radical chain mechanism used to explain vapor phase chlorination, and it is believed that direct fluorination proceeds by a non-ionic mechanism.

Chlorofluoropropanes, E. T. MCBEE, A. L. HENNE, H. B. HASS AND N. ELMORE, *Jour Amer. Chem. Soc.* **62** (1940) pp. 3340-1.

Propane was chlorinated to give $CH_3CCl_2CH_3$. This was fluorinated to give $CH_3CF_2CH_3$. The difluoride was chlorinated at low temperature in sunlight or artificial light, and also at high temperature in the dark; asymmetrical chlorination prevailed in all cases. Chlorination of $CH_3CF_2CH_3$ gave successively, $CH_3CF_2CH_2Cl$, $CH_3CF_2CHCl_2$, $CH_3CF_2CCl_3$, $CH_3ClCF_2CCl_3$, $CHCl_2CF_2CCl_3$, and $CCl_3CF_2CCl_3$. Fluorination of $CH_2ClCF_2CCl_3$ gave two new compounds, $CH_2ClCF_2CFCl_2$ and $CH_2ClCF_2CF_2Cl$. Chlorination of $CH_2ClCF_2CF_2Cl$ gave two new compounds, $CHCl_2CF_2CF_2Cl$ and $CCl_3CF_2CF_2Cl$.

Manufacture: Processes and Plant

Synthetic Glycerine from Petroleum, E. C. WILLIAMS AND ASSOCIATES, *Chem. & Met. Engr.* **47** (1940) pp. 834-8.

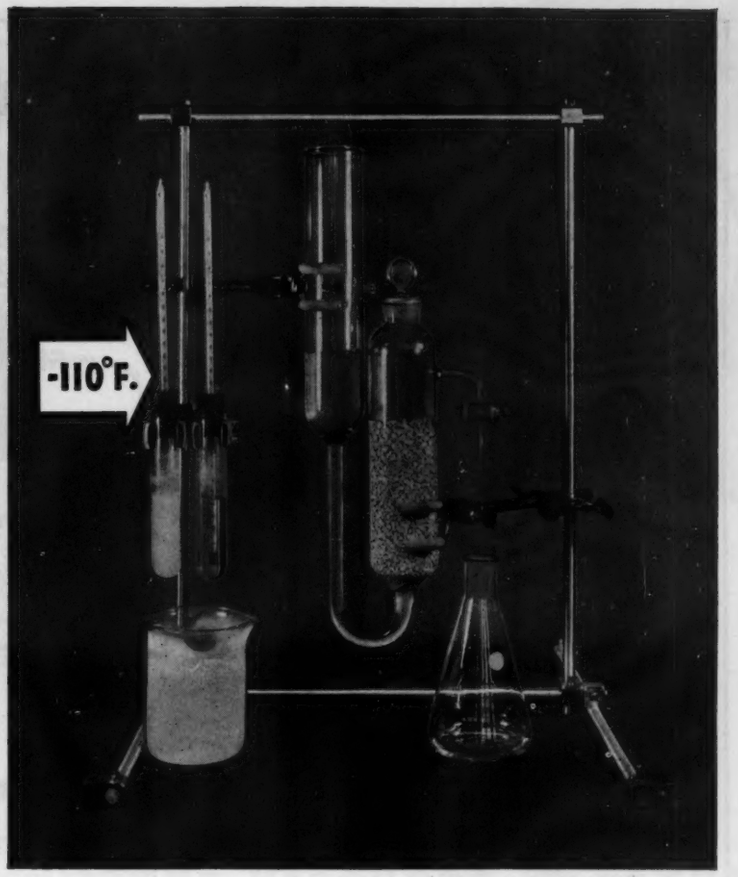
The economics of glycerine production and the attempt to synthesize glycerine on a commercial basis are briefly reviewed. Of the several possible syntheses the most direct are those starting with the three-carbon skeletons, such as propylene or propane, available in large quantities as a by-product in the petroleum industry. The synthesis used by the Shell Company starts with propylene and proceeds to allyl chloride, to allyl alcohol, or to glycerine dichlorohydrin, and thence to glycerine. The chemistry of, and the procedure used in, the several steps are described in some detail. Propylene is chlorinated at the relatively high temperature of 500°C., and the allyl chloride separated by extraction and distillation. In the second step of the synthesis allyl chloride may be converted to allyl alcohol, or may be chlorinated in aqueous solution by hypochlorous acid, yielding glycerine dichlorohydrin. The dichlorohydrin can then be hydrolized with caustic soda, or with caustic soda and lime, to glycerine. Production of glycerine by both of these routes is outlined. Purification of the glycerine finally obtained is deseribed. Final product meets all required specifications, and is stated to be equal to or better than any glycerine offered in the market.

National Power Show Report, EDITORIAL STAFF, *Chem. & Met. Engr.* **47** (1940) pp. 844-7.

The Editorial Staff of Chemical and Metallurgical Engineering review the new products

Visibility Unlimited

EVEN AT 110° BELOW ZERO F.



Those two test tubes clamped to the left end of the apparatus shown above, hold the proof that Alorco Activated* Alumina dries liquids DRY. The left-hand tube is filled with a low-freezing liquid (Carrene) containing a soluble acid and water; the right-hand tube holds this liquid after passage through the bed of Alorco Activated Alumina in the large glass U-tube. Immersion of the two test tubes in a beaker of Dry Ice at −110°F. caused the water and acid in the wet sample to freeze, and become cloudy and slushy. The Carrene dried with Alorco Activated Alumina remained clear and fluid, even at this low temperature. The thermometer figures are clearly visible through the liquid. Percolation through the Alorco Activated Alumina removed all the water and acid.

Out in the oil fields, Alorco Activated Alumina is doing a similar job of moisture removal every day—on a he-man scale. Dryers designed to use Activated Alumina are removing moisture from natural gas to dew points below −110°F. and in volumes as high as 25,000,000 cubic feet daily. By removing moisture, Alorco Activated Alumina is protecting natural gasoline plants, pipe lines, and many types of pressure equipment from valve freeze-ups and corrosion.

Alorco Activated Alumina, as well as the equipment designed to use it, is trouble-free and easy to operate. There are no solutions, evaporators, nor moving parts. With proper usage, the life of Alorco Activated Alumina is unlimited. Operation at pressures up to 3500 psi. is routine.

We shall be glad to send you information on present uses of Alorco Activated Alumina in the petroleum industry or consult with you on your drying problems. ALUMINUM COMPANY OF AMERICA (*Sales Agent* for ALUMINUM ORE COMPANY) 1963 Gulf Building, Pittsburgh, Pennsylvania.

*Registered Trade-mark

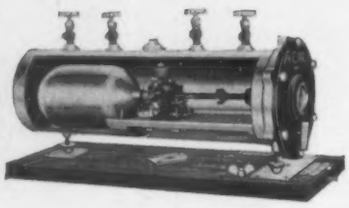
ACTIVATED ALUMINA

AN "ALORCO" ALORCO PRODUCT

GAS GRAVITY BALANCE

THE SERVICE ACCURACY R.S.C. TULSA

MOISTURE TESTER



The Ac-Me Specific Gravity Gas Balance is designed for use in the Laboratory, Plant or Field.

Four Spring Suspension is used, giving accurate results and maximum portability.

For Bottled Gas and other Liquefied Gas Products

Easy to Operate

The moisture content of gas passing through the Tester is shown by the color of indicating cartridge.

For Full Description of new Gas Testing Instruments and Laboratory Apparatus, write for Catalogue 26-A

THE REFINERY SUPPLY CO., Inc.

Manufacturers, Jobbers, and Importers

SCIENTIFIC LABORATORY AND POWER PLANT EQUIPMENT

621 E. 4th Street
Tulsa, Oklahoma—4-8144
L. D. 581

1309 Capitol Avenue
Houston, Texas—Fairfax 5814

If Your Gauges Can Take This—They Can Take Anything!

39,360 "PRESSURE JOLTS" PER DAY FOR 3 YEARS . . . . AND STILL IN PERFECT CONDITION

The Heart of the Gauge Gives Life to Its Performance

The LONERGAN refinery gauge has stamina built in. Tube is turned from specially refined tool steel. All parts of the movement are hardened, non-corrodible steel and are mounted on an integral forged steel socket. Shoulder screws are hardened stainless steel. For pulsating pressures there is a special dampening device.

Special movements to meet specific conditions also furnished.

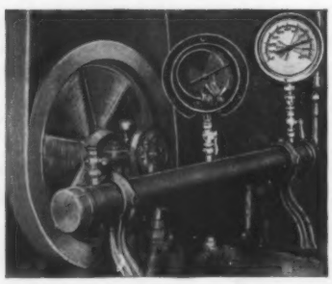
•

The LONERGAN line of gauges — including the new LONERGAN phenol case gauge that is moisture, dust and vapor-proof — are described fully in Catalog 600. Write for your copy and name of the nearest distributor.

Lonergan

VALVES - GAUGES - SPECIALTIES

300 Specialties for power plants • Since 1872



Think that over. Packed into a comparatively short time is service more severe than your gauges must endure in an average lifetime and *the LONERGAN Gauge shows no sign of its service age.* If that's the kind of gauge performance you're seeking . . . here it is, undeniably proved!

•

J. E. LONERGAN COMPANY

211 RACE STREET PHILADELPHIA, PA.

shown at the recent power show in New York particularly those that have been developed in the period since the last show two years ago. Considered in the report are: new instruments, pumps, valves, tubes and traps, power transmission, construction materials, insulation and refractories, electrical equipment, and a number of miscellaneous products. Names of the companies manufacturing the various products are given.

Applying Water Pumping Equipment to Process Pumping Problems, G. L. MONTGOMERY, *Chem. & Met. Engr.* **47** (1940) pp. 840-3.

The author shows how the newer types of centrifugal pumps are being used in process industry pumping applications. Improvements are such that it is no longer safe to assume that a new pumping problem should be solved along lines previously used. A number of special problems are discussed, as, for example, the pumping of brine from wells that give nautral gas along with the brine. The matter of avoiding gas binding is described. The application of pumps to mixing problems is discussed. The application of vertical pumps where saving of space is important is considered. The vertical centrifugal pump is finding many applications in refinery use, as in the handling of gasoline and butane. Special pumps in which the motor is isolated in a non-miscible liquid can be had. An application in which two pumps with submerged motors deliver butane at 85 to 125° F. against a 692 foot head is described. High pressure multi-stage centrifugal pumps are considered in relation to special pumping problems, such as the supplying of liquids in hydraulic press systems. Rotary pumps are briefly considered, as well as pumps handling mixtures of liquids and solids.

A Criterion for Knock in Gasoline Engines, R. C. PLUMB AND A. C. G. EGERTON, *Inst. Mech Engrs.* (London) *J. & Proc.* **143** (1940) pp. 247-60P.

The tendency of a fuel to knock in an engine is correlated with the physical conditions in the engine cylinder by use of the empirical function $pP\int_0^t r(P - Po)dt$ in which p is the mean gas density, P the absolute pressure and r the surface volume ratio at time t after the beginning of the reaction in the unburned end gas, and Po is the pressure at $t = 0$. Indicator diagrams were obtained from a single-cylinder engine fitted with an oscillograph and operated at incipient knock. The data so obtained were used to test the function. Tests were made at a jacket temperature of 100°; mixture temperature 35-80°; compression ratio, 4.90-8.23; speed, 600-1200 r.p.m.; spark advance 22-50°; fuel, 75 octane number gasoline and 57- and 81-octane number blends of n-hexane and isooctane; air/fuel ratio, as required to give incipient knock, or from 14 to 21. The maximum value of the function was found to be substantially the same for each of the 6 sets of conditions used for each fuel. The values varied from 0.07 to 0.20 for the 3 fuels. The authors feel that the results suggest the possibility of developing an absolute method of knock rating that would be independent of engine-running conditions. Similarly it was found that the ignition time lags, t_e, of the 2 hexane-isooctane blends in a bomb at 450°, at pressures from 28 to 49 pounds per square inch, gave nearly constant values for the function $pPr(P - Po)t_e$, with values of t_e ranging between 0.23 and 0.61 seconds.

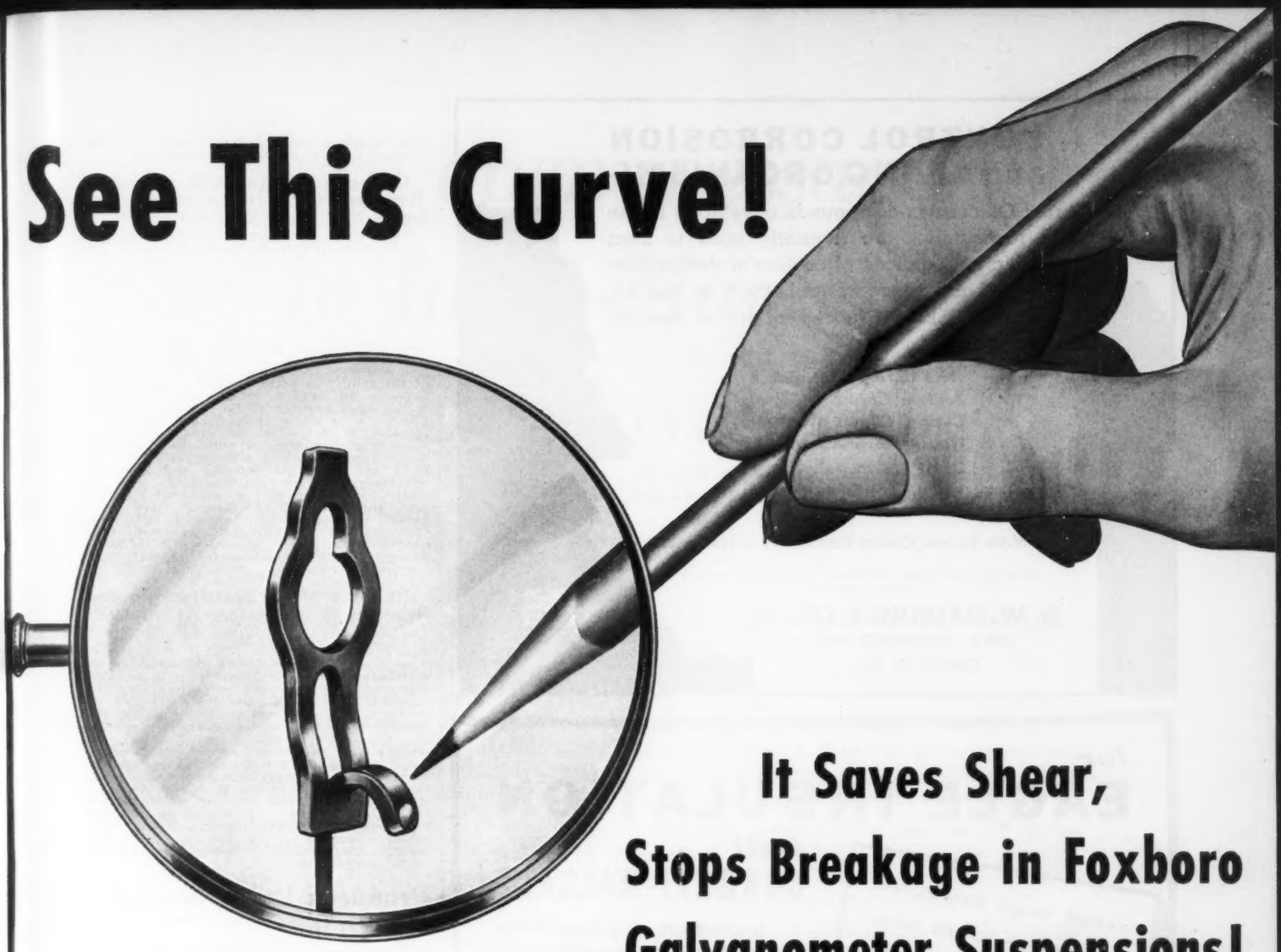
Determination of Organic Sulfur in Combustible Gas, F. M. ROGERS AND R. F. BALDASTE, *Ind. & Eng. Chem., Anal. Ed.* **12** (1940) pp. 724-5.

Several methods for the determination of organic sulfur in gas have been described, but none is applicable to the analysis of hydrocarbon gas containing 0 to 0.2 grains per 100 cubic feet. The method described has filled the requirements for a reliable, relatively rapid routine analysis of combustible gases. It is in some measure a modification of existing methods for the determination of organic sulfur. Purified air is used to burn the gas in a special burner, the sulfur dioxide resulting from the combustion of the gas is absorbed in sodium hypobromite solution, and the sulfate in this solution is determined turbidimetrically. The purification of the air is described, as well as the gas burner and absorber. The procedure is given in detail; a number of typical results are tabulated.

Maintenance in Process Industries, Chem. & Met. Engr. Report, *Chem. & Met. Engr.* **47** (1940) pp. 851-8.

The organization of plant maintenance work in the process industries is considered. The types of maintenance problems encountered, maintenance in relation to production, organization required for maintenance, types of work carried on in addition to maintenance, and means of anticipation of breakdown and repairs, are among the subjects discussed.

See This Curve!

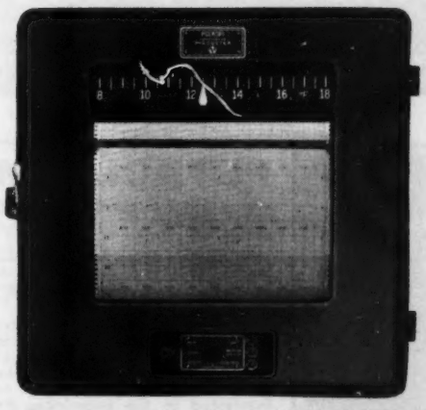


It Saves Shear, Stops Breakage in Foxboro Galvanometer Suspensions!

You can say "good-bye" to your pyrometer servicing troubles when you install Foxboro Potentiometer Recorders and Controllers. Even such fine details as galvanometer suspensions in these instruments are precision-engineered to save you inaccuracies and interruptions for replacements.

Take the specially-developed snubbing surfaces on Foxboro galvanometer suspensions, for one example. They're carefully curved and crowned to give shear-free contact with the gold strips. In addition, the strips themselves are longer, heavier, stronger . . . spot-welded, instead of soldered in place. Large-scale users of Foxboro Potentiometer Instruments say that these suspensions *"never break"!*

Trouble-free galvanometer suspensions are only one of numerous exclusive refinements that make Foxboro Potentiometer Instruments more sensitive and easier to maintain. Get complete factual data in Bulletin 190-4. **The Foxboro Company, 74 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branches in principal cities of the United States and Canada.



Foxboro Potentiometer Recorders and Recording Controllers are guaranteed accurate within ¼ of 1% of scale range.

RECORDING · CONTROLLING · INDICATING

FOXBORO

REG. U. S. PATENT OFFICE

Potentiometer Instruments

CONTROL CORROSION and LIVING ORGANISMS

The Chrom Glucosates compounds developed in the HAERING laboratories are regularly used to treat millions of gallons of cooling water for corrosion and algae control. Each of the following Chrom Glucosates has a specific application.

Acid Chrom Glucosate
Sodium Chrom Glucosate
Cupric Chrom Glucosate
Quachrom Glucosate

Send your samples to our laboratories in Chicago, Wichita, Kansas, and New York City for over-night service.

Write for our Chrom Glucosates brochure.

Have you investigated IN-HIB-CO, our new corrosion resistant coating?

D. W. HAERING & CO., Inc.
2308 S. WINCHESTER AVE.
CHICAGO, ILL.

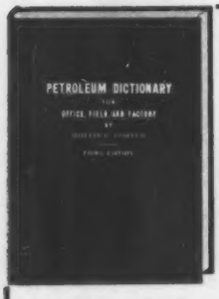
for
EAGLE INSULATION
Call
CORBETT-WALLACE

TAYLOR Forged Steel Flanges and Fittings • POWELL Valves • YOUNGSTOWN Pipe • PETRO Unions and Checks • GLOBE Boiler and Condenser Tubes • LAMSON & SESSIONS Rivets • EAGLE PICHER Insulation • STEEL, Structural and Plates.

Immediate shipment from our Houston warehouse of:
Eagle 66 and 20 Plastic Insulations
Eagle 99 Insulation
Eagle 111 Insulation
Eagle Insulseal
Eagle Supertemp blocks
Eagle Stalastic Boiler Setting Compound

(See Eagle advertisement on page 23)

CORBETT-WALLACE CORPORATION
Quality Products Plus Engineering Assistance
SAWYER AND WINTER STREETS • HOUSTON • PHONE CAPITOL 5327



PETROLEUM DICTIONARY

By HOLLIS P. PORTER, *A Registered Engineer*

3RD REVISED EDITION

This new edition of PETROLEUM DICTIONARY has been much improved. Many changes in the vocabulary of those employed in this rapidly developing industry have made additions and enlargements of the book necessary.

This book grew out of demands for some source of definitions for terms used by the petroleum industry. Previous editions have gone into the hands of executives, engineers, students of Petroleum Engineering, manufacturers, brokers and advertising agencies. It should be in the library of every one in any way connected with, or interested in the petroleum industry.

263 pages, 3541 words and terms defined, Size 6x9, Price postpaid $3.00

Send Check to

THE GULF PUBLISHING COMPANY
P. O. DRAWER 2608 HOUSTON, TEXAS

The report includes articles covering maintenance work in five typical industries.

Corrosion Control with Threshold Treatment, G. B. HATCH AND O. RICE, *Ind. & Eng. Chem.* **32** (1940) pp. 1572-9.

The effect of hexametaphosphate on the corrosion of iron is discussed. This is of importance in connection with boiler water treatment or in connection with the circulation of water in cooling systems. The threshold treatment of hexametaphosphate has found extensive application in the stabilization of waters that tend to precipitate calcium carbonate. However, in addition to the stabilization with respect to calcium carbonate, the treatment markedly inhibits the corrosion of iron and steel. For the quantitative evaluation of the inhibitive action of the treatment, the decrease in oxygen concentration that resulted upon passage of the water through a column of steel wool has been used as a measure of corrosion. The results obtained were in good agreement with the visual evidence from the tests with black iron pipe. Data are presented showing the effect of hexametaphosphate concentration, rate of water flow, presence of previously formed rust, and pH upon the rate of corrosion at normal tap water temperatures. It is believed that the effect of threshold treatment upon corrosion is caused by the adsorption of hexametaphosphate, or a complex thereof, upon the metal or metal oxide surface.

Recovery of Furfural from Aqueous Solutions, F. TRIMBLE AND A. P. DUNLOP, *Ind. & Eng. Chem., Anal. Ed.* **12** (1940) pp. 721-2.

In general there are two methods for the separation of the components of a solution, namely, distillation and extraction. Distillation has been used extensively for the recovery of furfural from aqueous solution. The authors describe a solvent extraction method to effect the separation of furfural and water. The extraction solvent proposed is ethyl acetate. The data are given for the systems furfural-ethyl acetate-water. An extraction procedure is described, and the quantity of steam required per unit weight of furfural is calculated. It is somewhat less than is required in the distillation process. Other solvents can be used in the extraction process, as, for example, various ethers and aromatic hydrocarbons.

Products: Properties and Utilization

Improvements in Cutting Oils, A. G. AREND, *Chem. & Ind.* **59** (1940) pp. 771-2.

The consumption of cutting oils has been greatly increased because of the vast expansion of machining generally to meet the needs of the armament drive. Cutting oils are expected to minimize the power consumed, provide lubrication between the tool and the work, dissipate heat and cool both metal surfaces, increase the life of the tool, flush away turnings and chips, and prevent corrosion. The list of cutting mediums includes alkaline solutions, fatty oils, blends of fatty oils with mineral oils, and sulphurized mineral oils prepared under varying conditions. The uses of the different oils, and the requirements of different metals and alloys are briefly discussed.

Hydraulic Fluids. Fundamentals Affecting Circuit Efficiency, N. E. MILLER, *Product Eng.* **11** (1940) pp. 407-10, 450-4.

The viscosity, resistance to wear and the demulsibility of an hydraulic fluid should be adjusted to the particular system in which the fluid is used. The compressibility of oil varies with temperature and with the base type of the oil. The paraffin base oils from Pennsylvania have 10-20 percent greater compressibility than the Mid-Continent and Coastal oils.

British Standard Methods for the Sampling and Examination of Bituminous Road Mixtures (Revised August, 1940) No. 598-1940. Pp. 41, British Standards Institution, 28, Victoria Street, London, S. W. 1. Price 3s,6d.

The first issue of this British Standard was published in February, 1939. Experience gained since that time showed that a number of modifications were desirable. The size of the samples has been increased. The test for the determination of bitumen content has been revised. A modified test for the rapid determination of bitumen content that gives a good approximation is outlined in an appendix, and is useful for routine purposes. The section dealing with the identification of mineral aggregate has been completely revised.

Developments in Research and Technology of Bituminous Road Materials, G. W. ECKERT, *Assoc. Asphalt Paving*

*An open message to Johns-Manville Employees**

by LEWIS H. BROWN, *President, Johns-Manville Corp.*

AS THIS NEW YEAR BEGINS, I am glad to have this opportunity to discuss with you the big job facing all of us during 1941.

Because of the demands placed on every business and every citizen by our nation's need for an adequate defense, our work is clearly cut out for us. We must contribute to the utmost of our ability to the defense building program.

Already, one-third of all J-M production is demanded for defense requirements. And this demand is growing daily. Some of it has been due to the increased need for J-M products for direct government projects. Some of it is the result of sales to expanding industries which use our products and are themselves working at top speed to fill government orders.

* * *

With every increased demand Johns-Manville has stepped up production to meet it. Many departments of our seventeen mines and plants have been affected by the defense needs and are now operating seven days a week, 24 hours a day. The working day is divided into three shifts of eight hours. At many locations, four shifts of employees work 40 hours each week to assure full production of the machines 7 days a week. Thus, work on Saturdays and Sundays is distributed fairly among everybody affected.

As the defense program develops we will necessarily have to step up our production more and more. This means we will have to find all the "bottlenecks" and increase the productivity of every machine.

Of course, most of us would prefer that industry's policy could be "business as usual." But these are not normal times. Business cannot be conducted "as usual" in an emergency. Defense comes first.

* * *

As a company, J-M is not going to let anything or anybody stand in the way of expediting the government's efforts to complete the defense program. This means co-operation by all of us, by management and by employees.

Naturally we shall all be called upon to make sacrifices. Taxes will be heavier. Raw material and manufacturing costs will probably rise. We shall all have to bear the burden.

Under these circumstances we shall have to redouble our efforts to reduce waste and increase efficiency so that we not only will be able to deliver quality goods in record time, but keep prices in check. By doing this we shall be helping to keep the costs of the defense program down. As taxpayers we shall indirectly benefit through this economy, for all of us must pay our share of the enormous defense bill.

* * *

There is no doubt in my mind that J-M jobholders can be relied upon to do their part. You have already shown the spirit of real co-operation and patriotism which is so necessary. For your co-operation I want to thank you.

I know that I can count upon your continued support and loyalty in our common effort to help keep this land of ours safe and free.

May I take this opportunity to wish for all of you health and happiness during this new year?

Lewis H. Brown

**Although not directly engaged in the manufacture of munitions or armaments, Johns-Manville manufactures many products essential to the operation of industries so engaged. This message, stating Johns-Manville's policy in support of the nation's defense program, originally appeared in the January, 1941, issue of the* News Pictorial, *J-M employee magazine.*

Tech., Proc. Tech. Sessions 11 (1940) pp. 365-433.

The author reviews the literature for the year 1939. The patent literature is divided into 6 groups: manufacture of asphalts, use of solvents, blending, addition reagents, emulsions and paving construction; this part contains 99 references. The second part is divided into 15 groups, including chemistry, physical properties, liquid asphaltic materials, emulsions, tars, weathering, adhesion, heterogeneity, admixtures of rubber with bitumens, testing of bitumen-aggregate mixtures, bituminous surfacing, soil stabilization, recovery of bitumens and reviews.

Neutral Oils from Coal Hydrogenation, A. EISNER, M. L. FEIN, AND C. H. FISHER, *Ind. & Eng. Chem.* **32** (1940) pp. 1614-21.

Using 5 cc. samples of oil and a shaking machine the action of sulfuric acid on cracked gasoline, a coal-tar distillate, and neutral oils produced by coal hydrogenation was studied. The effect of acid concentration, acid-oil ratio, agitation time, and other variables were determined. Plotting the acid concentration against the amount of oil extracted gave curves with two plateaus that can be used to characterize neutral oils. A convenient and reproducible method of characterizing small samples of neutral oil, that consists in locating the levels of the two plateaus by two successive extractions with 86 and 98.5 percent sulfuric acid, is suggested, and the probable errors involved are indicated. The levels of the plateaus indicate roughly the amounts of olefinic, aromatic, and saturated hydrocarbons present, and the values estimated in this manner are similar to those obtained by older methods that require more oil, reagents and time. Sulfuric acid extractions show that aromatic hydrocarbons predominate in coal-hydrogenation oils and that the aromatic content increases with increase in molecular weight.

The Clement-Pigneguy Knock Indicator, D. M. CLEMENT AND P. G. PIGNEGUY, *Jour. Inst. Petr.* **26** (1940) pp. 489-513.

A long-felt need in motor-fuel testing has been an indicator of knock intensity that is unaffected by combustion pressure, and in which the functioning of the instrument does not require the interdependent setting of its component parts. The C.F.R. bouncing-pin apparatus is described in detail, and it is found that the knock-meter readings are always influenced by the movement of the diaphragm under combustion pressure. The knock-meter records the movement of the pin in the first few oscillations only of its total vibrating period. The indicator described by the authors is shown to possess the desired qualities. Testing can be effected over the entire octane scale without alternation of the original setting. Although the construction may appear to be similar to the bouncing-pin indicator, the changes in principle involved are fundamental; firstly, the recording of all pin movement is relative to the diaphragm; secondly, the time of bounce of the pin off the diaphragm is measured by means of an extremely small current by including the pin and the diaphragm in the recording circuit in place of the leaf-spring assembly. It is claimed that the apparatus measures the true knock intensity over the entire testing range of octane numbers; that combustion pressure effects are not recorded; that the sensitivity per octane number is controllable; that the current, 0.027 milliampere, is so small that there will be no trouble caused by arcing at the contact point; that the maintenance of the apparatus is negligible, and that its operation is much simpler than that of the standard pin.

DURALOY

Castings Alloyed and Poured to Help Keep Stills "on Stream"

Alloyed with proper percentages of chromium, nickel, iron and other elements to give maximum resistance to heat and corrosion.

Poured with the skill of experienced alloy steel foundrymen to give sound castings throughout.

Heat-treated under instrument control to produce proper grain structure.

Duraloy, with its experience in just this kind of work dating back to 1922—a work in which it has always specialized—is a dependable source of supply for your chrome-iron, chrome-nickel castings not only for tube supports but for any other purpose.

THE DURALOY COMPANY

OFFICE AND PLANT: SCOTTDALE, PA.

Eastern Office: 12 East 41st St., New York, N. Y.

Detroit: The Duraloy Co. of Detroit
St. Louis: Metal Goods Corporation
Scranton, Pa.: Coffin & Smith
Los Angeles: Great Western Steel Company

Findings as to Power Alcohol

After long study of the proposal to use alcohol as a part of motor fuel the Committee on Motor Fuels of the American Petroleum Institute has made its report, which summarized as follows:

"The power alcohol idea has been under consideration for over 30 years but is no more practicable today than it was at the beginning.

"Alcohol cannot be manufactured from farm products under present and prospective conditions for less than five to six times the cost of gasoline.

"A mixture containing 10 percent of alcohol would consequently cost around 3 cents a gallon more than straight gasoline.

"Use of a 10 percent mixture would increase the nation's fuel bill by $690,000,000.

"The claim that technical advantages of alcohol-gasoline fuels justify their extra cost is not supported by facts.

"Europe's experience with alcohol mixtures instead of proving their value as proponents have claimed, shows clearly that the scheme is not economically sound.

"Because farmers buy one fourth of the motor fuel consumed, because relatively few could actually sell products to alcohol distilleries, and because of adverse influences on sales of other products, on soil fertility, and on independent farming, the net effect of the power alcohol scheme on farmers' interests would be adverse.

"Pretensions that alcohol is needed as a substitute for irreplaceable oil supplies are answered by the fact that petroleum reserves are greater today than ever before, while conservation methods are still improving rapidly. Also that methods already developed of synthesizing oil from coal assure a continuing supply of oil as far into the future as any need can be foreseen, at cheaper prices than are in prospect for alcohol."

Gasoline Line In Operation

The gasoline pipe line of Shell Oil Company from the Fall River terminal to the Boston area has been put in operation. The 59-mile line is the first to serve Boston. It has capacity of 10,000 barrels daily.

For you and U. S. A.

Year by year demands for motor fuel have grown and quality standards have gone up

Year by year Universal has kept ahead of them through untiring research, invention and development

Year by year, opportunity for refiners has broadened as better methods to produce greater values from a barrel of crude were developed and made available to all

Now, as always, U. O. P. is ready Efficiently, speedily and abundantly new processes will make special defense products, superoctane fuel for fighting airplanes, butadiene to produce better rubber than trees ever grew, toluene, vital ingredient of TNT, and floods of motor gasoline and fuel oil needed by our defense forces and the industrial machine behind them

All these processes are available to all American refiners through Universal

Where do you fit in the picture?

Universal Oil Products Co
Chicago, Illinois

Dubbs Cracking Process
Owner and Licensor

New Equipment for the Modern Plant

Flue Still Hose

THE B. F. GOODRICH COMPANY

A flue cleaning hose designed for use in refineries and chemical plants, designed for use with air up to 125 pounds pressure or with steam up to 80 pounds pressure, has been announced by B. F. Goodrich Company, Akron, Ohio.

The hose is of rough bore construction with synthetic frictioned fabric and synthetic oil-resisting tube, asbestos cover and both internal and external wire winding. The synthetic tube is designed to keep out oil which causes deterioration, and the rough bore construction to protect against collapse. Use of internal and external wire winding is designed to prevent kinking or twisting of the hose when coiled or while cleaning tool is in the tube. The external wire guards against tearing of cover by abrasive scale.

Furnace

PETRO-CHEM DEVELOPMENT COMPANY

A furnace of tubular design, designated Iso-Flow, with heating elements placed symmetrically around the burners and tubes equidistant from the flame burst, has been announced by Petro-Chem Development Company, 120 East 41 Street, New York.

Radiant and convection heat to each section of every tube is controlled to obtain practically uniform rates of heat transfer for every square foot of heating surface. The surface nearest the flame-burst is subjected to a controlled amount of radiant heat to obtain uniform rates, and the remainder of the surface is subjected to varying proportions of direct radiant, secondary radiant and convection heat.

Cylindrical walls are completely covered by the heating elements to effect a low temperature behind the tubes and to practically eliminate setting maintenance and to permit use of standard light-weight insulating material.

The furnace is available in three standard designs: Type A is of all-radiant design; Type B is radiant design with convection zone, and Type C is the Type A or B units with air heater.

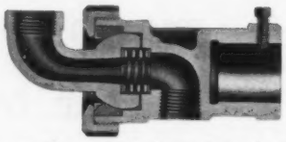
Furnaces up to 15,000,000 b.t.u. heat absorption per hour are prefabricated and completely shop assembled for shipment, while for larger duties the furnaces are prefabricated and shipped in large segmental sections for simplicity of field assembly.

Petro-Chem Iso-Flow Furnace

Swivel Joint

BARCO MANUFACTURING COMPANY

A swivel joint rated for pressures to 1500 pounds and providing for a 360-degree movement around an axis at right angles to the inlet and outlet, has been announced by Barco Manufacturing Company, 1801 Winnemac Avenue, Chicago.



Barco's Type 7KS-8BS Swivel Joint

Designated Type 7KS-8BS, it is available in pipe sizes from ⅜- to ¾-inch. A socket-equipped body is employed that permits the coupling to be anchored in position. The device is designed for use with oil, water, air, gas and steam without leakage under alternating high and low temperatures.

Speed Reducer

THE AMERICAN PULLEY COMPANY

A speed reducer consisting of a helical-gear reduction unit which mounts directly on the shaft of the driven machine and a standard belt drive between the motor and the input shaft of the reduction unit, has been announced by The American Pulley Company, Philadelphia.

The unit has a standard fixed ratio of 13/1, with any greater or lesser ratios accomplished by the primary belt drive. In application, where an overall reduction ratio of 52/1 is desired, for example, a belt drive is selected with a ratio of 4/1.

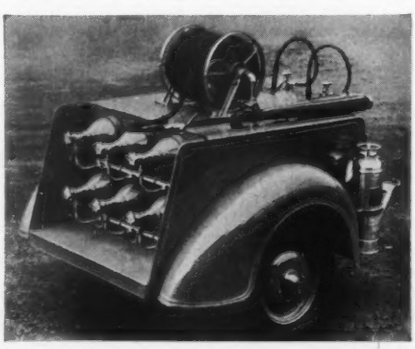
Five reduction units cover applications from ½- to 30-horsepower, and provide speeds between 11 and 215 revolutions per minute.

Fire-Fighting Unit

WALTER KIDDE & COMPANY

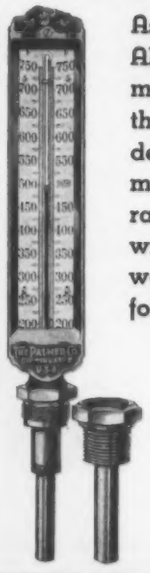
A portable fire-fighting unit, designed to be hooked up as a trailer for emergency use and carrying six 50-pound carbon dioxide cylinders, a hose reel and nozzle, has been announced by Walter Kidde & Company, Bloomfield, New Jersey.

Cylinders, manifolded together, are individually operated by valves on each

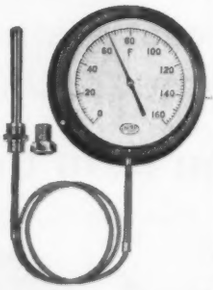


Kidde Portable Fire-Fighting Unit

ESSENTIAL *To National Defense . . . Are* **FINE TEMPERATURE INSTRUMENTS**



As important as proper food for the ARMY are good Temperature Instruments that help to build and maintain the equipment necessary in modern defense work . . . And PALMER Thermometers will stand the tests for accuracy because they have been made with A-1 materials, by highly skilled workmen and are thoroughly annealed for lasting accuracy.



(Write for new editions: No. 200-F and No. 300-D Catalogs)

See detailed data, page 261, 1940 Refinery Catalog

THE PALMER CO.

Manufacturers: Indicating, Laboratory, Dial and Recording Thermometers

2513 NORWOOD AVE., CINCINNATI NORWOOD, OHIO

Canadian plant: King & George Sts., Toronto

KEEPING RETURN BENDS OFF THE REPLACEMENT REQUISITIONS

Return bends in an oil refinery can be either a direct aid to economical operation or a constant drain on the maintenance account. Into which classification they fall depends on the service they give and the frequency with which they appear on replacement requisitions.

Return bends made from 4-6 per cent Chromium-Molybdenum steel qualify in the first category. The steel has good corrosion resistance and retains its strength at elevated temperatures. The Molybdenum content eliminates temper brittleness.

All three qualities are important from the service standpoint, the last named particularly so. It means that bends can be safely cooled to ambient temperatures before removal for cleaning.

Chromium-Molybdenum is one of several Molybdenum steels which are demonstrating their value in day-after-day refinery operation. Complete data on them is contained in our book, "Molybdenum in Steel", a copy of which will be sent free on request to those interested in improved materials.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • CALCIUM MOLYBDATE

Climax Molybdenum Company
500 Fifth Avenue • New York City

MOLY

cylinder, permitting employment of all or any part of the unit's capacity on a large or a small fire. Carbon dioxide is discharged through 100 feet of ½-inch hose, fed through a trunnion-type manifold. Control of the discharge may be made by a shut-off valve on the nozzle handle, permitting discharge to be interrupted while operator is maneuvering for position against a blaze.

For smaller fires, two portable carbon dioxide extinguishers of 15 pounds capacity are carried on the front platform of the trailer. Also two 2½-gallon pure-water extinguishers which operate on the principle of a syphon bottle, each containing a small cartridge of carbon dioxide which is released when the extinguisher is inverted, and which propels a water stream 30 to 40 feet.

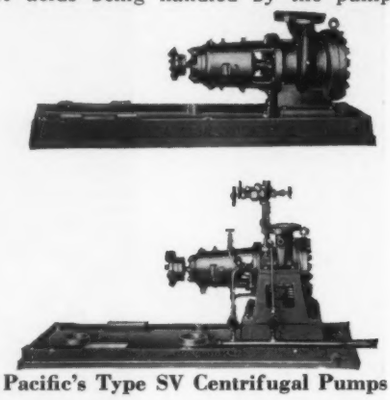
Pumps

PACIFIC PUMP WORKS

A line of general service centrifugal pumps, designated Type SV and designed to meet a wide variation in pumping conditions, has been announced by Pacific Pump Works, Huntington Park, California.

One style, designed for temperatures down to sub-zero with both heavy and light liquids, is foot-mounted, while another style for high temperature is centerline-mounted. Capacities range from 25 to 1400 gallons per minute against discharge pressures up to 300 pounds. The pumps are designed for maximum casing working pressure of 600 pounds, and for handling liquids up to 750° F. at speeds ranging up to 3600 revolutions per minute. Pumps for hot service, employ water-cooled bearings, stuffing boxes and base pedestals, with provision for removable lagging if desired.

Parts coming in contact with liquids or acids being handled by the pumps



Pacific's Type SV Centrifugal Pumps

can be fabricated of different types of materials to resist corrosion. The units are furnished with vertical suction and discharge openings. By removing the shell head on the front side, impeller and all wearing parts within the pump may be inspected, replaced and renewed without disturbing the drive or any of the piping connections.

Adaptable to any type of drive and supplied with bases to accommodate any make of driver, the pumps are equipped with heavy-duty, double-row, radial and ball thrust bearings, arranged for ring-oil lubrication. They may be supplied with or without auxiliary piping for water-cooling and lantern ring seal oil lubrication.

Milling Head

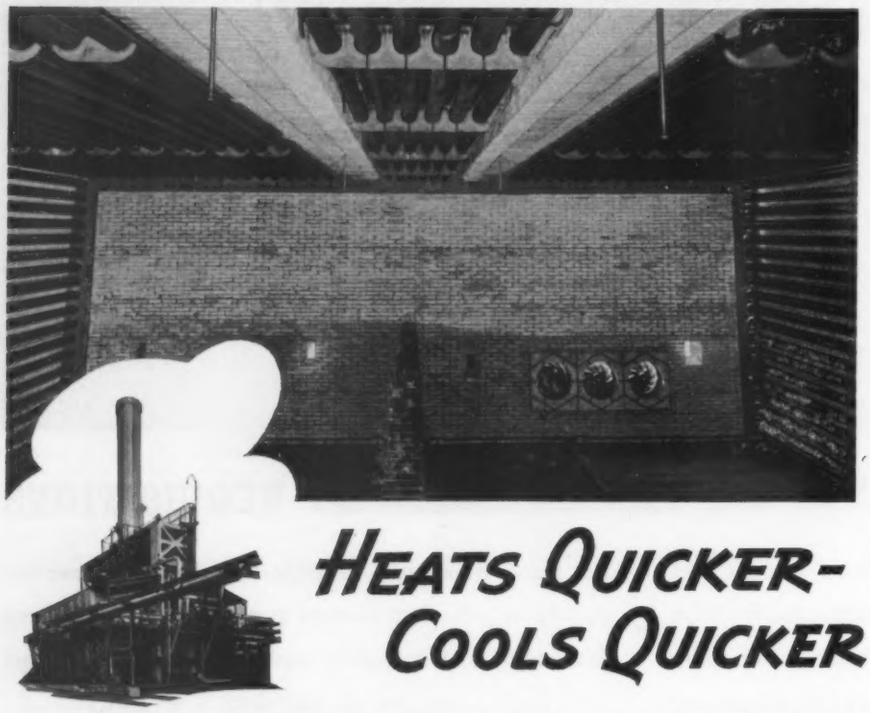
GLOBE PRODUCTS MANUFACTURING COMPANY

A milling attachment employing the lathe spindle for its drive and the carriage movements to operate its table, has been announced by Globe Products Manufacturing Company, 3380 Robertson Boulevard, Los Angeles.

The spindle of the attachment is carried on a vertical slide for positioning or moving up and down. Accessories include a ball-bearing arbor support for attachment to the lathe tailstock spindle so a cutter arbor can be applied in a

Globe Products' Milling Attachment

In this combination visbreaker, burner walls are protected by Armstrong's A-26 Brick, backed up by 1½" insulating block. End and convection walls use Armstrong's A-23 Brick, also backed up by 1½" insulating block. Roof is Armstrong's A-23 Brick, backed up by 1½" plastic insulating cement.



HEATS QUICKER—
COOLS QUICKER

. . . thanks to LIGHTWEIGHT Armstrong's Insulating Fire Brick

KELLOGG Supported Arches and Walls are featured in this combination visbreaker designed and built by the Kellogg Engineering Corporation. Efficient Armstrong's Insulating Fire Brick were used to minimize heat loss, aid temperature control, and increase operating efficiency.

These lightweight Armstrong Brick save time and money because of their low heat storage capacity. Furnaces heat up quickly—cool off quickly. Repairs and replacements can often be made without taking the furnace out of production for more than a few hours. Another important "plus" feature of Armstrong's Brick is the fact that they can easily be cut and shaped right on the job. This means that a few standard sizes can be kept in stock for repair purposes, instead of a great number of odd sizes and shapes.

All Armstrong's Brick constantly meet high standards for crushing strength, thermal conductivity, tensile strength, spalling resistance, and other qualities—to assure satisfactory service in almost any high temperature process. For all the facts about Armstrong's complete high temperature line including cements, write now to Armstrong Cork Company, Building Materials Division, 1001 Concord Street, Lancaster, Pa.

Armstrong's
HIGH TEMPERATURE INSULATION

Color now aids the easy and accurate identification of the five types of Armstrong's Brick

manner similar to that on a standard plain milling machine with an overarm. Design also permits mounting a chuck on the end of the arbor at the milling head in raised position for setting a standard lathe tool on a block on the carriage to swing larger work in a turning operation than the lathe will take on its own headstock.

The spindle, mounted on ball bearings, is driven by V-belt sheaves and belts connecting to a sheave on the lathe spindle in an arrangement which permits vertical positioning through a 6-inch distance above the table. Overall dimensions of the table, which clamps to the cross slide on the lathe carriage, are 4½ x 12 inches.

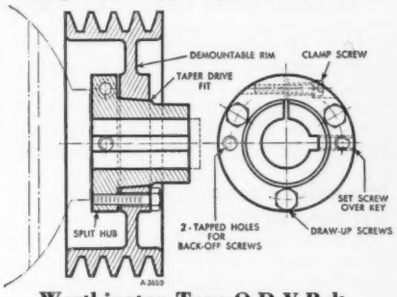
The milling head is available for Atlas and Craftsman lathes, other than 6-inch sizes; 9- and 11-inch South Bend lathes, and 10- and 11-inch Sheldon lathes. It may also be attached to other makes of lathes, and larger sizes of lathes, by use of a special adapter base plate.

V-Belt Sheave

WORTHINGTON PUMP & MACHINERY COMPANY

A V-belt driver sheave incorporated as a standard item in its Multi-V-Drive line, designed for applications where quick-mounting of sheave to shaft, and dismounting from shaft, are desirable, has been announced by Worthington Pump & Machinery Corporation, Harrison, New Jersey.

Designated Type Q-D, each sheave



Worthington Type Q-D V-Belt Driver Sheave

unit consists of two parts, a longitudinally-split or clamp hub and a V-grooved rim. The hub is clamped to the shaft by means of a cap screw in its flange and is fastened by a standard keyway. A fit equal to a press fit, on shafts up to ten-thousandths over-size or under-size, is provided. The rim is taper-fitted to the hub and is fastened with three draw bolts.

To remove the rim, the draw bolts are withdrawn and two of them are inserted in holes so tapped in the rim that the bolts act as jamb screws and bear against the hub to force the rim off the taper without disturbing the position of the hub. No pounding or prying is required to remove either the rim or the hub.

The sheaves are available in the complete range of standard driver sizes.

Transformer

WAGNER ELECTRIC CORPORATION

A transformer, designated Noflamol and employing a non-inflammable synthetic liquid for transformer oil, has been announced by Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis.

The units are designed for installation indoors without use of fireproof vaults.

Brine Testing Set

YORK ICE MACHINERY CORPORATION

An improved brine testing set utilizing the colorimetric method with universal indicator has been announced by York Ice Machinery Corporation, York, Pennsylvania.

The set features sharper, more permanent color standards, small comparator block, provision for specific gravity determinations, addition of phenolphthalein for quick checks and to determine if samples out of the pH range are acid or alkaline, and a more convenient carrying case.

The set employs 11 color standards covering a range of 5 to 10 pH in ½-pH increments. Arrangement is provided for compensating colors in testing colored liquids such as dichromate-treated brine.

The set includes, besides the 11 color standards and bottle of indicator, a bottle of phenolphthalein, three test tubes, a thermometer with a range of —30° to 120° F., 1 x 6-inch glass cylinder, and hydrometer with specific-gravity range of 1.05 to 1.25, covering the range of calcium and salt brines.

Blueprinter

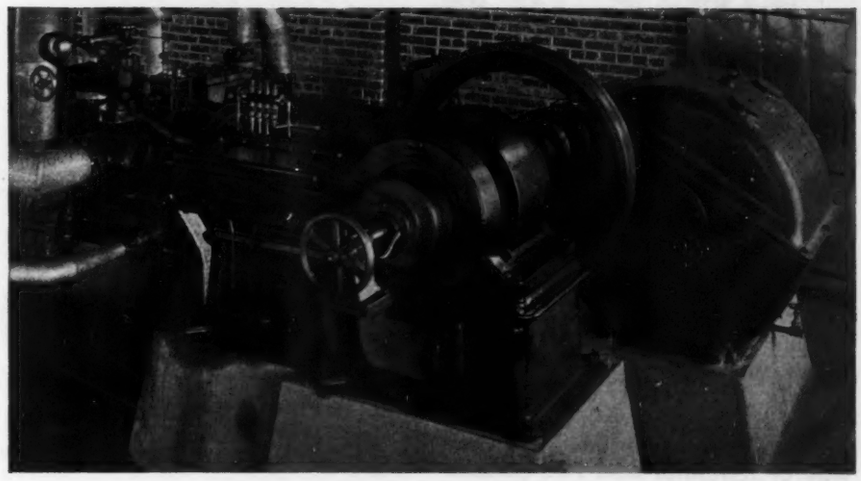
THE C. F. PEASE COMPANY

A continuous blueprinting machine, designated Model 22-16 and designed for industrial and other applications, has been announced by The C. F. Pease Company, 2601 West Irving Park Road, Chicago. The unit consists of the company's Model 22 printer and Model 16 washing and drying machine. It permits

Steam Engines as Pump Drives

Maximum

DEPENDABILITY, ECONOMY and MECHANICAL ADVANTAGES



During the past few months, many Troy-Engberg Steam Engines have been bought by oil companies all over the country for driving pumps.

Maximum dependability, economy, and mechanical advantages were the compelling reasons. Absence of fire hazard was another factor.

But the interesting fact about these engines is that the same advantages apply generally when used for driving all sorts of equipment such as compressors, fans, blowers, and generators.

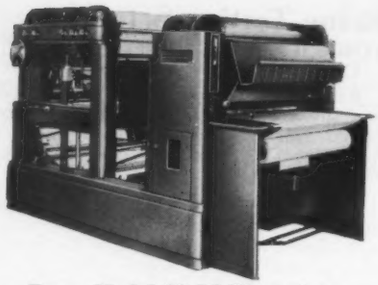
Write for our catalogue which gives full details of both horizontal and vertical engines rated up to 225 h.p. single and 450 h.p. duplex.

TROY ENGINE & MACHINE CO.

ESTABLISHED 1870 — 965 RAILROAD AVE., TROY, PA.

use of slow blueprint paper, to make possible better and more permanent prints.

Features include a sliding contact to smooth out inequalities in all tracings and give 24¾ inches of uninterrupted exposure area; three-speed lamp control to permit lamps to be operated on 10, 15 or 20 amperes, as desired, and avoid frequent dryer heat changes; Actinic arc lamps to furnish uniform light emission, burning for 45 minutes without interruption and resuming instantaneously; horizontal water wash to float exposed paper horizontally, free from tension and wrinkles; chemical applicator to give a change-over from blueprints to negatives in 30 seconds, or vice versa, and provide a method of applying potash to one side and hypo to both sides of the paper, and five 8-inch aluminum drying drums heated either with gas or electricity to provide gradual drying without distorting the paper.



Pease Model 22-16 Blueprinter

Filter

STAYNEW FILTER CORPORATION

A water filter employing radial fin construction, designated Model CPHLS, has been announced by Staynew Filter Corporation, Leighton Avenue, Rochester, New York.

Staynew's Radial Fin Filter Insert

In operation, water passes through fabric filter mediums designed for minimum restriction to water flow. A filter insert, measuring 11 inches high by 8¼ inches in diameter, provides an active filtering area of 1325 square inches. The filter has no moving parts, and is designed for long periods of operation without attention. The insert may be removed by unbolting the head and removing one wing nut, and units may be arranged so that cleaning is effected by backwashing with clean water.

Lock Nut

SECURITY METAL PRODUCTS, INC.

A lock nut, designed for repeated application without losing its gripping power, has been introduced by Security Metal Products, Inc., 374 East Kalamazoo Avenue, Kalamazoo, Michigan.

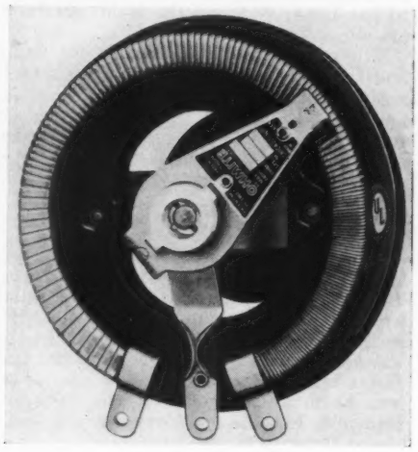
Security Metal's Lock Nut

The gripping element consists of a slightly eliptical-shaped spring-steel retainer, permanently sealed in the head of a standard nut. The retainer is distorted to circular shape by the bolt.

Rheostat

OHMITE MANUFACTURING COMPANY

A generator field control rheostat designed to provide smooth, close, gradual control of generator voltage has been announced by Ohmite Manufacturing Company, 4835 Flournoy Street, Chicago.



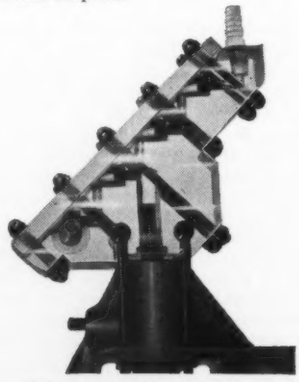
Ohmite's Field Control Rheostat

They are available tapered or uniformly wound, designed to provide control for separately or self-excited generators. They are supplied in 10 sizes, from 25 to 1000 watts, and feature compact vitreous enameled construction.

Plastic Pump

MILTON ROY

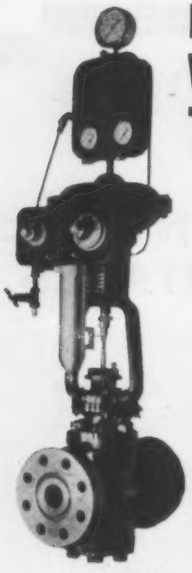
A transparent plastic pump for handling dilute acids, hypochlorites and other chemicals has been announced by Milton Roy, 1325 East Mermaid Avenue, Philadelphia.



Milton Roy Plastic Pump

The pump is machined from a solid block of plastic material, and features visibility at all times of the flow of liquid being pumped and the movement of the valve checks and pump piston. The plastic provides a natural resistance to chemical attack.

The pump features a flat-plate cover which, when removed, permits cleaning the complete valve assembly without disturbing pipe connections to the pump. Units are available in capacities of from ½ to 20 gallons per hour.



HANLON WATERS Type 303

Supply Regulator Panel

is designed to unitize and simplify piping hook-ups on field installations of reducing regulators, back pressure regulators or time cycle controllers.

THIS panel is a compact mounting for the high and low pressure operating medium regulators and drip chamber, attaching to any HANLON-WATERS motor valve diaphragm casing. One connection to the controlled pressure side of regulator and two connections from the panel (controlled pressure and operating medium) are the only connections required in the field.

THE H-W TYPE 303 SUPPLY REGULATOR SIMPLIFIES PIPING — SAVES TIME AND MATERIAL COST—OFFERS 100% SALVAGE.

Specify HANLON-WATERS Control Equipment with Type 303 Supply Regulator Panel on the next Regulator installation.

• ASK THE MEN WHO OPERATE THEM — THEY ARE OUR BEST SALESMEN!

Complete information and prices available at your nearest HANLON-WATERS Branch.

HANLON-WATERS, INC.

TULSA, OKLAHOMA

New York, Chicago, Pittsburgh, Philadelphia, St. Louis, Denver; Shreveport and Lafayette, La.; Fort Worth, Houston, Corpus Christi, Longview and Odessa, Texas.

Packings

THE B. F. GOODRICH COMPANY

Two types of sheet packing, one made of Ameripol, synthtic rubber developed after 14 years of research, and the other of Koroseal, synthetic elastic material, have been announced by The B. F. Goodrich Company, Akron, Ohio.

The Ameripol product is a dark packing designed to resist action of oils, heat and cold, and to resist water absorption. Tensile strength is approximately 1500 pounds, elongation 400 percent, and Shore durometer hardness 78 to 92. It is made to order only in 100-pound rolls, approximately 36 inches wide in thicknesses from 132- to 1/4-inch. A square yard of the 1/16-inch size weighs approximately 4¾ pounds.

Koroseal packing is designed to resist action of oils and solvents, and of some corrosives. Tensile strength is about 2200 pounds, elongation 300 percent, and Shore durometer hardness 73 to 77. It is furnished in 26 x 36-inch sheets, with the 1/32-, 1/16-, 1/8- and 3/16-inch sheets carried in stock and other thicknesses made to order.

Photo-Electrode Control

THE BROWN INSTRUMENT COMPANY

A method of protection against failure of oil, powdered coal and luminous gas flames, designated Protectoglo photo-electrode system, has been announced by The Brown Instrument Company, Wayne & Roberts Avenues, Philadelphia.

It employs a photo-electric principle that avoids the necessity of placing a metallic electrode in the flames. The system detects presence of a flame by means of light emitted when a burner is in normal operation.

The heart of the system is a light-sensitive device. In operation, light from the flame is directed upon a photo cell, resulting in a small flow of current through the cell which is amplified by a vacuum-tube circuit until of sufficient magnitude to close a relay. Through the relay contacts, the main fuel valve is energized.

Response of the system to flames of different luminosity may be changed on the job by means of a sensitivity adjustment. With the adjustment in the maximum position, the unit will respond to the light of a candle, while at the other extreme, with the adjustment at the minimum position, no amount of light will close the relay.

To prevent transient flame disturbances from causing unnecessary shutdowns, the system has been designed to provide a time lag in the relay operations, provided by the discharge of a small capacitor at the right of the sensitivity adjustment. The unit is designed so the time lag bears a direct relation to flame luminosity and to the setting of the sensitivity adjustment. For a given sensitivity setting, time lag is designed to increase with an increase in light intensity of the flame. Similarly, if the light intensity remains constant, increasing the sensitivity will also increase the time lag. The lag may be varied from zero to a maximum of 10 seconds.

The unit is supplied with a swivel mounting that can be screwed to a length of 1¼-inch pipe supported from the floor. The advantages of such a mounting are described as isolating the unit from the heat of the burner and furnace wall, and providing a ready means for sighting on the flame.

The system is designed to protect a luminous flame against explosion hazards. It is supplied for 115 volts, 25 to 60 cycles, inclusive. It is furnished as a cut-off model, for manual restarting.

Brown's Photo-Electrode Control

Gloves

MILLER RUBBER COMPANY

A line of neoprene-coated canvas work gloves in knit-wrist and gauntlet types has been announced by Miller Rubber Company, Akron, Ohio.

The gloves are designed to resist oils, fats and greases, and to offer a tough wearing surface. The knit-wrist glove is wrist length, while the gauntlet type is 14½ inches long, including a 6-inch gauntlet.

New

AIRETOOL CATALYST TUBE CLEANERS

CLEAN CATALYST TUBES SAFELY WITHOUT PROTECTIVE CLOTHES

Gone is the danger of severe burns from cleaning catalyst tubes! Gone is the danger of tube corrosion! Gone is the necessity of slowing down operators with heavy rubber clothing and respirators! Airetool's new Catalyst Tube Cleaners eliminate these dangers and inconveniences. The spent catalyst is cleaned out and deposited in receptacles connected with the cleaner's discharge opening or removed by an exhaust fan or conveyor system.

***In a recent demonstration* of the Airetool Catalyst Tube Cleaner, the cleaning time was actually reduced 75%. The labor cost was cut 50% and dust was eliminated from the surrounding atmosphere.**

Airetool Catalyst Tube Cleaners* are being made for vertical reactor tubes, catalyst converter and tower type units. Each is guaranteed to perform properly and eliminate the present operating hazards. *Our new Bulletin FR-59 tells the complete story. Send for it at once.

★

OTHER AIRETOOL REFINERY SPECIALTIES

TUBE CLEANERS
TUBE JIGS
PLUG SEAT PROTECTORS
TUBE GAUGES
CALIPERS
POLISHING AND BUFFING MOTORS
TOOL TRUCKS
PLUG RACKS

★

AIRETOOL MFG. CO.
SPRINGFIELD, OHIO
Representatives in Principal Cities
NEW YORK OFFICE — 50 CHURCH ST.

MONEY SAVING
News FOR REFINERIES
AND PRODUCERS

LOW-COST WAY TO DE-SCALE REFINERY EQUIPMENT

Are you using raw commercial acids to remove insulating scale deposits and rust from refinery equipment?

Why not play SAFE . . . and save money at the same time by using far safer Oakite Compound No. 32. Used as directed by our Service Representative, it dissolves deposits that prevent proper heat transfer on vacuum condensers, cooling coils, water-cooled booster pumps, compressors, ammonia condensers, water side of oil coolers, Diesel engine water jackets. Operating costs are lowered . . . efficiency is increased.

Save Time . . . Money ON THESE JOBS, TOO!

Cleaning the safe, low-cost Oakite way opens up many opportunities for savings too, on such other jobs as washing oil drums, salvaging dirty valves and fittings, removing sludge deposits from heat exchangers. Interesting data gladly mailed on request. Won't you write today?

OAKITE PRODUCTS, INC.
50B Thames Street, New York, N. Y.
Representatives in All Principal Cities of the United States and Canada

OAKITE *Certified* CLEANING

BUSINESS NOTES

United States Stoneware Acquires Federal Clay Products Company

The United States Stoneware Company, Akron, Ohio, has acquired The Federal Clay Products Company, Mineral City, Ohio.

The newly-acquired company has been incorporated as The Federal Refractories Corporation, and will continue its line of fire brick, refractories, and high-temperature cements. The plant will be expanded to handle the business of The United States Stoneware Company on tower packing rings, spiral rings, acid-proof brick and lining tile, while the company's Tallmadge (Ohio) plant will be used for acid-proof piping, tank linings, process equipment, jar mills, acid-proof tanks, and pumps. New equipment is being installed.

Arthur G. McKee Opens New Cleveland Headquarters Building

Arthur G. McKee & Company opened a new headquarters building at 2300 Chester Avenue, Cleveland, February 1.

The new building has approximately 34,000 square feet of floor space. It is of two stories, with one main section and two wings. Construction is of brick, steel and concrete. The building is air conditioned for year around operations, and has electric fluorescent lighting. Two drafting rooms are located on the second floors of the wings, and each can accommodate 80 draftsmen. Estimating and other engineering offices are on the second floor of the main section. On the lower floor of one of the wings, space has been provided for about 50 tracers and the remainder of the first floor space of both the main section and the wings of the building is for administrative, sales, accounting, purchasing and clerical purposes.

It is expected that both the company's new facilities and the company's former offices at 2422 Euclid Avenue, Cleveland, will be fully utilized at least during the duration of the present national emergency. The dollar volume of contracts taken by the company covering design and construction of oil refineries, blast furnaces and steel plants during the past year was twice that of the largest previous year in its history.

The company is now increasing its force of engineers, designers and draftsmen to meet the additional needs for current and pending contracts. In this connection, the company has established an engineering personnel division whose function will be to plan for future needs of engineers for both office and field work.

Blackmer Pump Company Announces Plant Addition

Contracts for an addition to its plant and office building have been awarded by Blackmer Pump Company, Grand Rapids, Michigan, according to N. J. Harkness, executive vice president.

The new addition will double the engineering department space, increase office facilities, and add somewhat to the testing and production departments. The building will be of brick and concrete construction, to harmonize with the present buildings. Contract calls for completion, ready for occupancy, by March 1.

Arcos Corporation Doubles Stainless Electrode Capacity

Arcos Corporation, Philadelphia, has announced an addition to its stainless electrode manufacturing plant which will give it approximately 100 percent increase in capacity. The new units have been in partial operation since mid-January, and will be completed by mid-February.

Gulf Coast Petroleum Laboratory Established at Houston

Gulf Coast Petroleum Laboratory, Inc., has entered the Gulf Coast area with headquarters at 1215 Dumble Street, Houston, to provide refiners and

One of two drafting rooms, each accommodating 80 draftsmen, at new headquarters of Arthur G. McKee & Company.

AND NOW IT'S "STANDARD" WHERE HIGH CAPACITIES ARE REQUIRED FOR PUMPS IN HAZARDOUS LOCATIONS

THEIR EXPERIENCE WORKS FOR YOU

For more than 50 years, Westinghouse engineers have worked side by side with every branch of the petroleum industry, to develop electrical equipment to meet your specific requirements. Take advantage of this experience and ability on your next electrical problem.

This Westinghouse explosion-resisting motor for refinery and pipe line service was the first large motor for "Hazardous Locations" to be built without the use of forced ventilation or external cooling equipment. Instead, it employs the long-proved dual ventilated frame originally developed by Westinghouse.

The design met the industry's needs so completely that it has now become "standard"—proved by the purchase of more Westinghouse motors of this type than those of all other manufacturers combined. It is available in ratings up to 1000 hp, 3600 rpm.

More than *electrical* ability was required to design these motors. Our engineers constantly study the petroleum industry and its needs. They appreciate the jobs that motors do—and what breakdowns can cost. So, they build electrical equipment in the light of this practical experience.

That's why it always pays to talk with your local Westinghouse representative when you have an electrical problem. You get "high test" ability that is ready to go to work for you. Try it, for your next electrical need.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO.
EAST PITTSBURGH, PA.

J-94383

Westinghouse

ELECTRICAL PARTNER OF THE PETROLEUM INDUSTRY

W
WESTINGHOUSE ELECTRIC

"VULCAN SUPERIOR" TONGS handle BOTH pipe and fittings

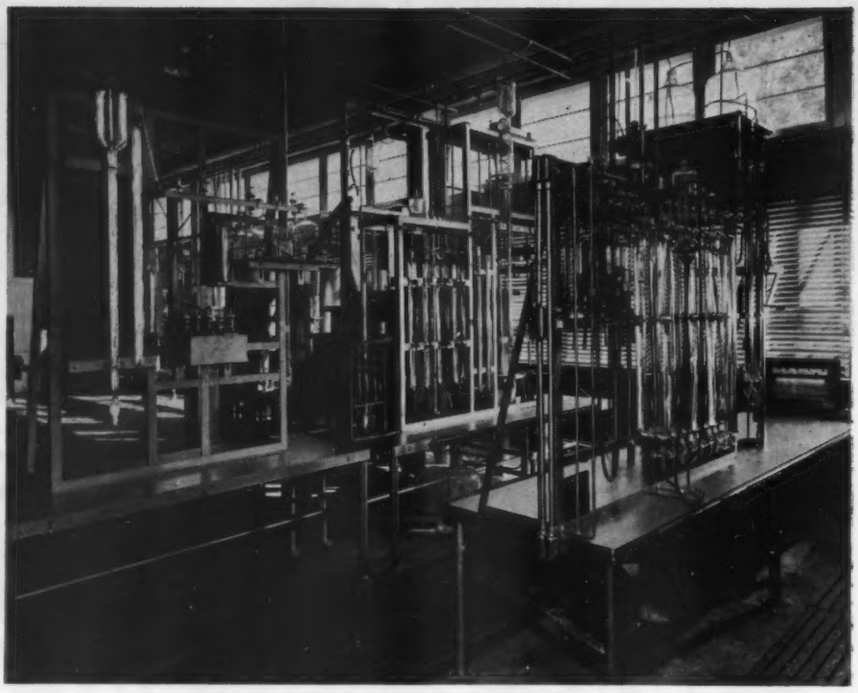
Here is the unbeatable tongs for Refinery use.

"Vulcan Superior" is a universal service tongs for both pipe and fittings—TWO tools in one. You can switch from one to the other *instantly*—no parts to change, no adjustments to make. Seven sizes, with either flat link or cable chain, handle pipe and fittings from ⅛ to 12 inches. Fully guaranteed. Write for complete Williams' catalog or see our advertisement in the Composite Catalog. Buy from your supply store.

J. H. WILLIAMS & CO.
225 LAFAYETTE ST. NEW YORK

Headquarters for: Drop-Forged Wrenches (Carbon and Alloy), Detachable Socket Wrenches, Reversible Ratchet Wrenches, Tool Holders, "C" Clamps, Lathe Dogs, Eye Bolts, Hoist Hooks, Thumb Nuts and Screws, Chain Pipe Tongs and Vises, etc., etc.

WILLIAMS
SUPERIOR DROP-FORGED TOOLS
VULCAN SUPERIOR
PIPE AND FITTINGS TONGS



Interior view of the Gulf Coast Petroleum Laboratory is shown above, with exterior of the plant shown at the right.

producers with facilities for analyses of petroleum and its products.

Complete facilities are available for making gas analyses, and for testing and evaluating all types of petroleum products. An experienced technical staff is maintained, and high- and low-pressure containers are available for taking gas and liquid samples.

Hercules Takes Additional Factory Building at Canton

Acquisition of a four-story factory building adjoining its property has been announced by Hercules Motors Corporation, Canton, Ohio. Work of reconditioning the plant to accommodate expanding production requirements has begun, and plans call for beginning operations in the new unit by April 1.

In taking over the property, the company adds 164,000 square feet of factory floor space to its present facilities, and approximately seven acres of property to its present tract. It gives the company possession of an industrial island in the center of the city covering approximately 16 acres.

Wm. B. Scaife & Sons Change Firm Name

Wm. B. Scaife & Sons Company, Oakmont, Pennsylvania, has changed its firm name to Scaife Company. The change, made for simplification, does not affect corporate structure or management of the company.

Organized in 1802 by Jeffery Scaife, the original shop was in what is now downtown Pittsburgh. The name, Wm. B. Scaife & Sons was first used in 1871, and "Company" was added in 1901. In 1892, the plant was moved to Oakmont, suburb of Pittsburgh.

Monsanto Chemical Announces New Defense Plant

Monsanto Chemical Company has announced plans for erection of a new chemical plant adjacent to its present plant establishment at Monsanto, Illinois. The cost of the plant is to be defrayed by the government, which will retain title to the buildings and installations. The site for the new plant is ground owned by the company, leased to the government without charge. Products of the plant are to be furnished the government at cost.

Chemicals to be produced at this plant are to be used in connection with the manufacture of gas protective equipment for troops. These chemicals have no known commercial application and it is mutually desirable that ownership of the plant be vested in the government.

Revere Copper & Brass Announces Defense Award

Revere Copper & Brass Incorporated, 230 Park Avenue, New York, has announced the Revere Award, to consist of nine cash prizes totaling $10,000 to be given American workmen in the metal industry for suggestions that will do most to accelerate the country's industrial defense program.

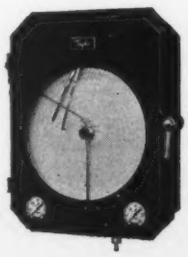
A 20-page booklet has been issued describing the award, giving a list of prizes, stating who may enter, and explaining for what it will be given. Five judges have been chosen, representing science, labor, industry, and the Army and Navy.

You Can Get **Not 1 but 5 Forms of Control** in the **NEW TAYLOR FULSCOPE CONTROLLER**

THE NEW Taylor Fulscope Controller is unique. It can *grow* in your plant. It can grow as your processing needs grow. At first your processing needs may be simple, so you install the simplest form of the new Fulscope. As time goes on, perhaps your production expands, and your processing operations become more demanding. You need a different controller. What to do? Buy another instrument? You don't need to! Another unit assembly may be added to or substituted in your basic Fulscope Controller. That converts it into the controller your progressing needs require. You see, merely by adding or substituting such unit assemblies in the drilled and tapped Fulscope cases, it's possible to expand the Fulscope Controller to give all types of process control—from simple *fixed high sensitivity*, through *adjustable sensitivity, adjustable sensitivity with automatic reset*, to *adjustable sensitivity with Pre-Act*, (Taylor's amazing new control effect based on rate of control-point deviation) and *adjustable sensitivity with automatic reset and Pre-Act*, the ultimate in process control. You may never need such advanced control, but Taylor has it if you want it. The new Taylor Fulscope Controller is industry's 5-in-1 controller for *all* kinds of process control.

There's a national need today for this astonishingly versatile, adaptable Fulscope Controller. Industry's biggest job is helping America prepare fast. You must be prepared to produce top quality at top speed. With this new Taylor Fulscope Controller in your plant, you *are* prepared. No other process controller is so completely new—none has been so completely redesigned (not just tinkered with)—no other is so easily adaptable to growing, changing processing needs. Your own preparedness program can well begin with the new Taylor Fulscope Controller.

Ask the Taylor man what the 5-in-1 features of the new Fulscope mean specifically to *you*. Find out about the recording and indicating types—for temperature, pressure, flow, and liquid level. Learn about the new Taylor Recorder, twin of the Taylor Fulscope Controller. *Now*—from Taylor Instrument Companies, Rochester, N. Y. Plant also in Toronto, Canada.



Not 1, but all these 5 Forms of Control Available in the NEW TAYLOR FULSCOPE CONTROLLER

Fixed High Sensitivity—Adjustable Sensitivity—Adjustable Sensitivity with Automatic Reset (in same case)—Adjustable Sensitivity with Taylor's unique Pre-Act effect Adjustable Sensitivity with Automatic Reset and Pre-Act

All Fulscope Controller cases are drilled and tapped to permit adding or substituting different forms of control—easily, right in the field!

BE PREPARED with TAYLOR INSTRUMENTS

Taylor

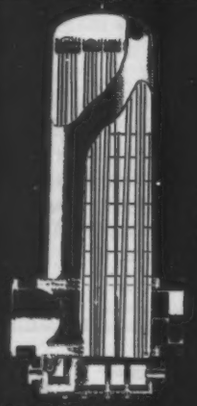
Indicating Recording Controlling

TEMPERATURE, PRESSURE, FLOW and LEVEL INSTRUMENTS

DAVENPORT WOOD SOLES are designed for use in refineries where underfoot conditions are too tough for ordinary soles. WOOD SOLES provide safer footing on slippery floors and rough, uneven surfaces. Tough maple soles, cut for comfortable walking, long outwear ordinary soles. Also special shoes designed to meet your particular requirements. It will pay you to investigate DAVENPORT WOOD SOLE SHOES. *WRITE for FREE CATALOG and latest prices!*

F. J. STAHMER SHOE CO.
2351 Boles Ave. Davenport, Iowa

LEACH
FRACTO
CONDENSERS
for High Pressure
and Temperature.



Also Heat Exchangers for Vacuum and Atmospheric Service.

Fracto Control

Patented in the United States and Foreign Countries

C. H. LEACH CO., Inc.
117 Liberty Street, New York, N. Y.

Supply Personals

J. W. Gardner, board chairman of Gardner-Denver Company, was recently honored on completion of 60 years service with the company by an award of a gold, diamond-set watch-fob model of a steam governor. He joined the company founded in 1854 by his father, the late Robert W. Gardner, as a boy of 17, starting as an apprentice machinist. His service includes nearly 30 years as president, and in more recent years, as executive committee chairman and board chairman.

J. W. Gardner

L. A. Mullen has been made manager of sales of tubular products for Pittsburgh Steel Company, Pittsburgh. He has been associated with the company since January, 1938, first as assistant district sales manager at New York, later as district sales manager at Chicago, and for the past year as assistant manager of sales in Pittsburgh. Before joining the company, for ten years he had been associated with Republic Steel Corporation in various sales capacities.

L. A. Mullen

H. H. Wilson, sales manager of Frick-Reid Supply Corporation, Tulsa, has been made a vice president, with headquarters shifted from Tulsa to Houston. He entered services of the company in July, 1920, at Tulsa, served in several branch stores, and for a number of years was manager of the company's office at Dallas. He had been sales manager since June, 1938.

H. H. Wilson

Rainey Elliott, formerly manager of the company's Dallas office, who entered the employ of the company in January, 1935, has been named to succeed Wilson as sales manager. He will transfer his headquarters to Tulsa.

H. L. Wilkins, former general district sales manager with headquarters at Mount Vernon, Illinois, has been named manager of branch stores, to be located at Tulsa.

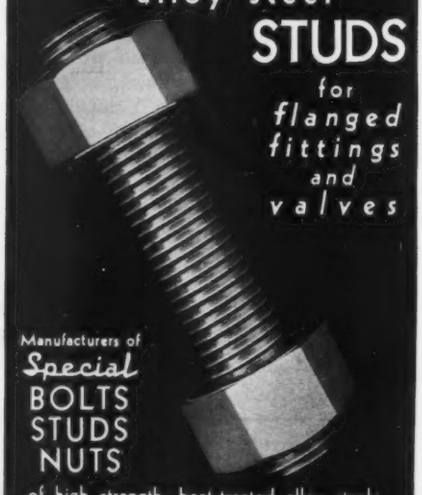
F. J. Kopp, former Panhandle district sales manager has been named manager of the Dallas and Fort Worth offices, and stores formerly in the Panhandle district have been placed in the Southern Oklahoma-North Texas District under H. D. Stanley, sales manager at Wichita Falls.

J. W. Kane, former Gulf Coast assistant district manager, has been made sales manager of the company's new Southwest Texas district, with headquarters at San Antonio; U. G. White, Jr., Mt. Vernon, Illinois, has been named Illinois-Kentucky district sales manager, and R. R. Boyer, Mt. Pleasant, has been named Michigan district sales manager.

G. Donald Spackman has been appointed general manager of Lukens Steel Company and its subsidiaries, according to Robert W. Wolcott, president. Spackman was born June 29, 1895, at Coatesville, Pennsylvania, and attended Coatesville High School and Swarthmore College, graduating from the latter in 1917 with a B.A. degree. His mechanical engineering degree was awarded in 1924 by Swarthmore College. In 1919, he joined Lukens Steel Company, serving in the mechanical department and handling steam, hydraulic and combustion problems. In December, 1920, he was appointed fuel engineer, serving in that capacity until August, 1925, when he was appointed superintendent of the flanging department. In 1929, he was appointed assistant general superintendent. When the Lukenweld Division was formed in May, 1930, he was elected president, and in 1936 was appointed general superintendent of Lukens Steel Company.

G. D. Spackman

VICTOR
Heat-Treated
alloy steel
STUDS
for
flanged
fittings
and
valves



Manufacturers of
Special
BOLTS
STUDS
NUTS
of high strength, heat-treated alloy steels, corrosion and heat resistant alloys, non-ferrous metals and carbon steels for refineries, natural gasoline plants and manufacturers of refinery and oil field equipment.

Write for complete catalog!
VICTOR PRODUCTS CORP.
2641 Belmont Ave. • Chicago, Ill.

B. B. Williams resigned as president of The Cooper-Bessemer Corporation, Mount Vernon, Ohio, to become board chairman, succeeding E. J. Fithian, who resigned. Charles B. Jahnke, vice president and general manager for the past 2½ years, has been named president. Fithian, one of the founders of Bessemer Gas Engine Company and its president for several years, will continue as a director.

B. B. Williams

Williams, who will continue in an active capacity as head of the corporation, has been with the Cooper-Bessemer Corporation and its predecessor, C. & G. Cooper Company, for 40 years, starting as sales engineer. He was made secretary in 1912, became vice president and general manager four years later, and in 1920 was elected president. He retained that position when C. & G. Cooper Company was merged with Bessemer in 1929 to form the present corporation.

C. B. Jahnke

Jahnke joined the company in 1935 as chief engineer, and since July, 1937, has been vice president and general manager. A 1910 graduate of the University of Cincinnati, he was with Fairbanks, Morse & Company for 21 years, first as chief engineer and later as works manager of its plant at Beloit, Wisconsin. He jointed International Harvester Company in 1931 to take part in their program of developing diesel engines for farm machinery.

Tom H. Pike, Jr., west coast district manager for Tube-Turns, Inc., Louisville, Kentucky, has established permanent offices in Los Angeles, at 210 West Seventh Street. The entire west coast and territory inland as far as Salt Lake City will be serviced from the new office.

Orville T. Barnett has been named engineer of tests in the welding electrode department of The Metal & Thermit Corporation, New York. A chemical engineering graduate of Armour Institute of Technology, he was formerly associated with Carnegie Illinois Steel Corporation in its metallurgical control department, and later was with Black, Sivals & Bryson, Inc., Oklahoma City, where he had charge of shop inspection. He will have charge of all electrode test work, including manufacturing control testing at Jersey City and East Chicago plants, as well as research work on uses and applications of electrodes.

O. T. Barnett

Foster Dee Snell has been elected president of the Alumni Association of the graduate school of Columbia University. He received his M. A. degree there in 1922 and a year later was given his Ph.D. in chemistry. For the past 20 years he has been president of Foster D. Snell, Inc., a firm of consulting chemists in Brooklyn.

Harry A. Burdorf and Frank P. Rhame, vice presidents of Lunkenheimer Company, Cincinnati, Ohio, have been elected to the company's board of directors. Burdorf, who has been with the company since 1905, is vice president in charge of sales, and Rhame, who joined the company in 1919, is vice president in charge of sales engineering.

George Rinck, assistant Eastern sales manager for Caterpillar Tractor Company, Peoria, Illinois, has been named Eastern sales manager, succeeding Henry M. Hale, resigned. Kenneth Cox is taking over Rinck's former duties.

D. S. Mix has been assigned responsibility for media and publishers relations for General Electric Company, succeeding the late F. R. Davis.

Alfred W. Thompson was elected president, treasurer and general manager of The Ludlow Valve Manufacturing Company, Troy, New York, at a recent meeting of directors. Formerly vice president and general manager, he succeeds as president Livingston W. Houston, who has been associated with the

for SPEED, POWER and GUTS
ROTO is the Gun for YOU

Roto guns have what it takes to do a real tube cleaning job in refineries. They have all the speed and power you need to knock out the toughest coke—and faster than you ever did it before. Roto guns are available for all tube sizes and shapes up to 12" I. D., with keen, hard cutter heads for every kind of deposit from soft sludge to rock-hard carbon.

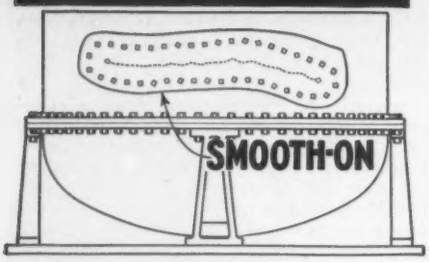
How about giving Roto a chance on your next cleaning job?

Model 112 Air-Driven Motor with self-feeding cage-type head and air valve for one-man operation.

See Our Adv. In Sweet's Catalog

The ROTO Company
145 Sussex Ave. Newark, N. J.

Emergency Repairs



The money-saving uses of Smooth-On No. 1 are almost endless. This many-purpose iron repair cement will seal cracks in process apparatus, heaters, pumps, valves, piping and machinery parts, will stop leaks at pipe connections, seams, bolts, rivets, screws, etc., and will tighten loose fixtures.

Buy Smooth-On No. 1 in 1 or 5-lb. can or 25-lb., 100-lb." keg.

To prevent or stop pipe joint leaks

on all types of connections

When leaks occur at screw-thread pipe joints, reassembly with Smooth-On No. 3 will assure a lasting seal *even if the threads are worn or damaged.*

On gasketed and other pipe connections, too, Smooth-On makes and keeps the joints tight, because this soft metal filler retains its body, does not dry, shrink or blow out, is not affected by steam, water, oil or gas.

Buy Smooth-On No. 3 in 1-lb., 5-lb. cans or 25-lb. kegs.

FREE

40-Page Repair Handbook

Every engineer should have a copy of this useful repair manual, with 170 diagrams and simple instructions for ingenious, practical shortcuts in emergency repairs and routine maintenance jobs. Write for your copy.

Buy Smooth-On from your supply house or if necessary, from us. For your protection, insist on Smooth-On — used by engineers since 1895.

Smooth-On Mfg. Co., Dept. 11
570 Communipaw Ave., Jersey City, N. J.

Do it with
SMOOTH-ON

company for 22 years and as president for the past eight years. Houston was elected board chairman and will continue in an active executive capacity in the management of the company.

Joseph H. Egolf, with the company for the past 50 years and treasurer for the past eight years, retired from active service. Other officers elected were Harry Hoffman, New York, a vice president, and John Ireland, Troy, assistant secretary and assistant treasurer.

John G. Martin and Richard C. Murphy have been named eastern and western regional managers, respectively, of Ethyl Gasoline Corporation in an expansion program described by J. Coard Taylor, vice president in charge of sales and advertising, as designed to effect closer coordination with the sales programs of oil and automotive companies. They will aid Harry W. Kaley, general sales manager, in directing the corporation's 10 division offices. Territories served by the Boston, New York, Dayton, Baltimore and Atlanta division offices comprise the eastern region under the direction of Martin, while the Chicago, Kansas City, Tulsa, Los Angeles and Seattle divisions will be under Murphy's direction.

J. G. Martin

R. C. Murphy

Murphy joined Ethyl Gasoline Corporation in 1929, became assistant manager of the New York division in 1935, and manager in 1936. Previously, he had served as field representative in the Baltimore, Boston, Atlanta and New York divisions. He was born in Olean, New York, attended Cornell University, and formerly was with the National City Bank in New York.

Martin began his service with the Company in March, 1927, as a field representative in the Middle Atlantic States. Transferred to the southwest, he supervised activities in Texas, Arkansas, Louisiana and Oklahoma, later becoming Tulsa Division manager. In 1932, he was assigned to specialized sales work in New York. The corporation's clinic system, of which he was made national director in 1937, was developed during his four years of experimental work in sales promotion on the West Coast.

P. A. McTerney has been appointed manager of sales for the large motor and generator division of General Electric Company's Industrial Department. He will have charge of sales of large direct-current motors and generators and motor-generator sets, as well as synchronous motors and AC engine and belt-driven generators.

M. C. Bellamy, since 1934 sales engineer of the Seattle office of The Timkin Roller Bearing Company, Canton, Ohio, has been made district manager of industrial bearing and steel sales for the Seattle territory.

ALL TYPES OF
EVALUATION
AND
GAS ANALYSIS WORK
WITH LABORATORY FACILITIES IN HOUSTON

A well equipped laboratory and experienced analysts operating under close supervision of our technical staff assure accurate results that are promptly obtained.

TESTED SAMPLE CONTAINERS
Furnished on Request
CALL WOODCREST 6-2679
OR WRITE TO

GULF COAST PETROLEUM LABORATORY, Inc.
1215 DUMBLE ST. HOUSTON

CHEMICAL ENGINEER

experienced in refinery engineering, including heat transfer and rectification calculations and high pressure process design. Location: Southwest. State age, education, experience, and salary expected.

Address
WRC, 1304-05 Hunt Building,
TULSA, OKLAHOMA

OIL BOOKS

The knowledge gained through years of work and study by some of the most capable men in the oil industry is set down in the various oil books published and sold by the Gulf Publishing Company. Catalog of these books furnished upon request.

THE GULF PUBLISHING COMPANY
P. O. Box 2608 Houston, Texas

WYACO
PRODUCTS
for the Petroleum Industry

—BAKELITE SPECIALTIES—

Pump Valves, Piston Rings and Rod Packing for Reciprocating Fluid Pumps, Air Compressors and Gas Compressors.

Corrosion resistance, durability, extremely low moisture-absorption, high insulating qualities and tensile strength characterize our Bakelite Products. Particularly desirable for non-lubricants.

Write for Bulletin and price list

INDUSTRIAL ENGINEERING SERVICE
310 Thompson Building
TULSA, OKLAHOMA

J. N. Kint, who formerly represented Worthington Pump & Machinery Corporation in the Los Angeles area, has been named to the sales force of Pittsburgh Equitable Meter Company and Merco Nordstrom Valve Company, according to H. Boezinger, district manager. He will represent the affiliated companies in the Southern California territory.

J. N. Kint

Louis R. Botsai has been appointed manager of the Gearing Department of the East Pittsburgh Division of Westinghouse Electric & Manufacturing Company, it was announced by A. C. Streamer, general manager of the division. For the past three years, Botsai has been sales manager of the company's Small Motor Division in Lima, Ohio, and before that he was for eight years sales manager of gearing apparatus at the Westinghouse Nuttall Works in Pittsburgh.

James Finley has been placed in charge of a new Cleveland engineering and sales office of The Vapor Recovery Systems Company, Compton, California. A mechanical engineering graduate of Loyola University, he is making his headquarters at 1010 Euclid Avenue.

William S. Shipley and Stewart E. Lauer were named board chairman and president, respectively, of York Ice Machinery Corporation when directors and stockholders held their annual meetings last month. Other officers named were Elmer A. Kleinschmidt, executive vice president; Samuel J. Shipley, vice president and treasurer; Llewellyn Williams, vice president, and Vincent K. Keesey, secretary. Appointments included John F. Lebor, assistant treasurer; Donald M. Magor, comptroller, and C. J. Malone, W. A. Pusch and T. A. Stebbins, assistant secretaries.

H A. Ward has been named Houston representative for Greene, Tweed & Company, New York. His headquarters are at 1420 Indiana Avenue.

Alex M. Brooks has been elected president of Chaplin-Fulton Manufacturing Company, succeeding W. S. Ralston, who died last July. A grandson of M. B. Chaplin, one of the company's founders, Brooks is the third member of his family to hold a responsible position with the company. His own active connection began in 1930, on his graduation from Sheffield Scientific School of Yale University. He became treasurer in 1934, on the retirement of his uncle, W. C. Chaplin, and was elected vice president in 1937.

A. M. Brooks

James G. O'Conor, recently of Washington where he has been active in an advisory capacity to the United States Ordnance Department, has been named president of Filtrol Corporation, Los Angeles. He succeeds L. R. Steander, who will remain active as a director. O'Conor completed 20 years of service with Gilbert & Barker Manufacturing Company, where he was foreign manager of manufacturing and sales. Earlier, he was connected with W. R. Grace & Company and with Westinghouse Electric & Manufacturing Company.

William B. Baylor has been made assistant district sales manager for Pittsburgh Steel Company at Los Angeles. Since September, 1936, he has been field engineer for the company in the Los Angeles district, and in addition to his sales duties in his new capacity, he will continue to carry on his engineering functions. Before joining the company, he was associated with Hughes Tool Company, Houston.

Robert Bischoff, formerly associated with Koppers Company in a sales and engineering capacity, has been appointed sales manager of The Ludlow Valve Manufacturing Company, Troy, New York, succeeding Joseph H. Egolf, retired.

John C. Chaffe has been appointed district manager of the Philadelphia office of Tube-Turns, Inc., Louisville, Kentucky. His office will cover an area that extends through Wilmington, Balti-

Vital In Refinery Service!

QUARTER TURN FOR SPEED
LEVER SEALED FOR SAFETY and SAVINGS!

HOMESTEAD
LEVER-SEALD
PLUG VALVES

Speed, safety, and savings are the much wanted advantages which you find in Homestead Lever-Seald Quarter-Turn Plug Valves. A quick turn of the upper lever (through a 90° angle) fully opens or closes the valve. An easy movement of the lower lever seals the valve against leakage, or prepares it for instant action even under extreme high temperature and pressure conditions, and thus assures safety in any emergency. No lubrication is required to seal these valves or to make them operate. Therefore, you save the time, labor and material expense of lubrication, and your profits increase. Get the advantages of Homestead Lever-Seald Valves on your next new job or replacement. Metals for every application include iron, steel, Monel, Ni-Resist, stainless steel, brass and others.

HOMESTEAD VALVE MFG. COMPANY
P. O. BOX 16, CORAOPOLIS, PA.

HOMESTEAD VALVES

Send for Valve Reference Book No. 38; and for special quantity prices on your valve requirements.

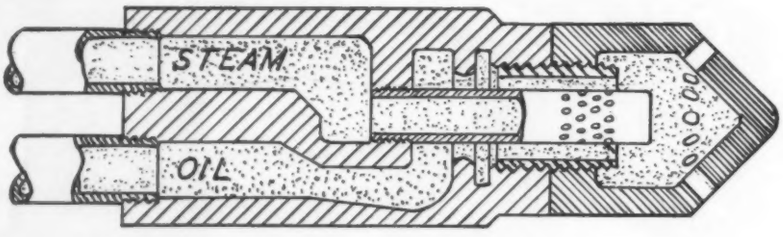
more and Washington. The Philadelphia office was simultaneously moved from the Lafayette Building to the Broad Street Station Building.

Ralph R. Newquist has been appointed manager of the Houston district office of Allis-Chalmers Manufacturing Company. Since joining the company in 1934, Newquist has been stationed in the district offices at Chicago and Pittsburgh, and more recently at Boston. Prior to that he was connected with several other engineering and electrical firms. He is an electrical engineer graduate of Pennsylvania State College. At Houston, he succeeds K. P. Ribble, who has obtained leave of absence for purposes of health.

Lawrence D. Bell, William J. Conners and Reginald B. Taylor have been added to the directorate of Sterling Engine Company, Buffalo, as membership of that body was increased from seven to ten. Other board members are Spencer H. Logan, chairman; Charles A. Criqui, vice chairman; Addison F. Vars, president; Edward H. Townsend, executive vice president and treasurer; Frank J. Raichle, secretary, and Frank G. Cooban and A. K. Barbee.

Harry J. Schultz has been appointed central regional manager of the construction equipment division of Worthington Pump & Machinery Corporation, with headquarters in Chicago. He was formerly manager of the contractors division of the Independent Pneumatic Tool Company.

JOHN ZINK . . . . . makes good Oil Burners too!



John Zink MT Oil Burner

The John Zink MT Steam Atomizing Oil Burner features a multiple tangentially drilled steam nozzle, which not only atomizes but spins the atomized oil. This procedure assures equal distribution of the fuel to all burner tip ports.

BURNS OIL LIKE A GAS BURNER — this is the one Oil Burner that produces a gas burner heat pattern.

As you would expect JOHN ZINK and his engineers manufacture a very good floor furnace.

JOHN ZINK COMPANY

Burners • Floor Furnaces • Unit Heaters

TULSA, OKLA. NEW YORK CITY

Wendell R. Carlsen has been named sales manager of Pacific Pump Works' centrifugal pump department for the Mid-Continent division. He will make his headquarters in the Commerce Building, Houston, and assist agents already established in the area.

William G. Shrive, Jr., has been named factory representative for Harvey-Whipple, Inc., in the New York metropolitan area, Westchester County, Long Island and Staten Island. He had been Eastern sales manager for McClave-Brooks Company for the past two years.

John J. Buckley has been named works manager of the Philadelphia plant of Sharples Corporation. He was formerly an executive of Taft Pierce Company.

Grover M. Herman, Jr., son of the board chairman and president of American-Marietta Company, Chicago, has been named to the company's board, while C. S. Beaver, general manager of the company's operations at Marietta, Ohio, and High Point, North Carolina, and Muir Rogers, manager of the Mid-Western industrial finishes division, were named vice presidents.

William C. Yates, manager of the control and renewal parts division of General Electric Company's industrial department since 1937, has been named assistant manager of the department.

M. P. Robinson, head of Robinson Filter Company, has joined Worthington Pump & Machinery Corporation to take charge of the company's newly organized water purification equipment division. Before establishment of his own company in 1937, he had been Eastern representative of International Filter Company, Chicago, for 17 years.

C. A. Childers, former engineer with Happy Belting Company, Tulsa, and more recently associated with The National Supply Company at Seminole, Oklahoma, has joined the engineering staff of B. F. Sturtevant Company, Boston. Childers will act as a contact man in the engine cooler department, and will establish a district office at a later date.

A. B. Morey, treasurer of Gisholt Machine Company, Madison, Wisconsin, for the past 4 years, has been named to a vice presidency. He is succeeded as treasurer by H. J. Homewood, accountant and office manager for the past 10 years. C. K. Swafford, general superintendent of the company, has been elected a director.

Clarence M. Doiseau has been named president of Cincinnati Ball Crank Company, succeeding Reamy C. Field, board chairman, who had been acting as temporary president. Doiseau joined the company in April as vice president and general manager.

J. Hal Marshall, formerly in the sales department of Composite Steel Division, has been named sales representative in the Buffalo district by Jessop Steel Company, Washington, Pennsylvania. He is a graduate of Marietta College, Marietta, Ohio.